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RESEARCH AND DEVELOPMENT IN THE UNITED STATES AIR FORCE

Report of a Special Committee
of the
Scientific Advisory Board to the Chief of Staff, USAF

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21 September 1949

General Hoyt S. Vandenberg
Chief of Staff, U. S. Air Force
Headquarters U. S. Air Force
Washington 25, D. C.

Dear General Vandenberg:

As a result of the statement which you directed to the Scientific Advisory Board at its April 1949 meeting, the Board appointed a special Committee to make an over-all study of USAF research and development activities. This Committee, whose membership is shown at the end of this letter, spent nearly two months in its investigations and discussions.

With this letter, I hand you the Committee's report. Its conclusions and recommendations have my full concurrence.

Your April 1949 statement to the Board goes to the heart of the problem of achieving effective technical progress in the USAF and stresses the importance of Air Force research and development as a vital factor in the national security. The Air Force is the arm which promises to play the major role in any war which we can now foresee. Unless that war takes place [illegible] within a very few years, we must fight it not with the weapons we have today, but with the weapons which research and development can put into our hands tomorrow. In fact, our margin over our potential enemies lies predominantly in the technical superiority which we now enjoy, and must maintain. It would be very dangerous for us to suppose that we can remain secure by making technical progress at anything less than the maximum rate of advance we can achieve.

The prominent role of the Air Force in preserving the national security cannot be long maintained if the Air Force falls behind in its research and development. We are now witnessing a profound change in the nature of air weapons, as flight speeds enter the supersonic regime and the long-range guided missile moves ever nearer to practical and effective realization. All three Departments of the Department of Defense are taking a keen interest in this development, and are supporting it vigorously. Leadership in this work cannot be legislated or proclaimed; it must be earned. The Air Force can earn it only by achieving, through research and development, technical and operational superiority in these new fields.

Full realization of the implications of the present trends has come to the Air Force at a time when it has been facing other major problems of extraordinary difficulty. The Air Force is only some two years old as an independent Department, and it has had to deal with numerous problems

of internal organization arising from its independence. The principles of Service unification have had to be worked out and adequate national support assured for the Air Force's primary mission of long-range strategic bombardment. Most immediately important, the Air Force has had to create, from the disordered fragments left by demobilization, an effective force-in-being capable of meeting the grave responsibilities of airpower in the support of national policy.

It is understandable that the Air Force, faced with such problems, should have given lower priority to its research and development activities. The Committee believes that this has been necessary in the past, but now that the immediate problems appear to be in hand, the Committee submits that the same competence, imagination, and vigor which have characterized Air Force operations must be brought to bear on USAF research and development matters. A really high priority must be given to the problems of creating an adequate organization and providing effective support for research and development.

The Committee found that the existing organization, personnel policies, and budgetary practices do not allow the Air Force to secure the full and effective use of the scientific and technical resources of the nation. Neither do they allow the use of Air Force civilian and military technical personnel to full advantage, nor do they permit deriving the benefit that the Air Force should derive from its relationships with the industries and the universities of the country.

The Committee was well impressed with the highly commendable and determined efforts on the part of some competent individuals in research and development to correct this potentially disastrous situation. However, only USAF-wide understanding of the serious nature of these problems and concerted action on the part of the entire organization can ever rescue Air Force research and development from the progressive deterioration it is now undergoing. This is readily apparent from the conclusions of the Committee which are presented in detail in the attached report. These conclusions tend to support the recommendations which have been made by various advisors to the Air Force over the last four or five years. Some of the more important points can be summarized as follows:

1. While the top command of the Air Force has on frequent occasions emphasized the crucial importance of technical progress, an understanding of the policies and organization necessary for making such progress has not yet been sufficiently diffused throughout the Air Force, nor have adequate steps been taken to implement the necessary policies and provide a suitable organization.

2. Fundamental research and initial development are now handled by a number of Commands and by several staff agencies, all of which are simultaneously responsible for different and quantitatively far greater jobs. The division of duties and responsibilities between the various Commands and the staff agencies is not sufficiently clear. Research and initial development have suffered because of the present situation.

3. Satisfactory progress in Air Force research and development can be made only when a single agency, headed and staffed by technically qualified personnel, is charged with this single purpose and is given the entire job. Such an agency should be directed to prepare and defend its own budget and personnel requirements, formulate personnel and administrative policies, and plan its facilities—all, of course within the broad framework of over-all Air Force plans, objectives, and allocations.

4. At present, funds used to support research and development work are drawn from many different budgetary sources, most of which are quite outside the control of those responsible for research and development. This practice should be revised to provide for the unified budgeting of all costs, including housekeeping and indirect costs, involved in research and development, and for the control of this budget by the single agency mentioned above. While this change would result in an apparent increase in the costs of research and development, it would lead, in fact, to a balanced and more effective program, and would produce greater efficiency and actual savings.

5. The Air Force presently has far too few officers with technical qualifications, despite the highly technical nature of the Air Force mission. Even the present inadequate number of technically qualified officers are not used now in the most effective way. Both of these difficulties can be traced to the belief, general among officers, that career advancement cannot be secured by excellence in technical work, that there is no sound Air Force policy to utilize highly-trained officers in technical jobs, and that opportunities for promotion in and for technical work are far from equal to those offered in other Air Force duty. It is my belief that a proper and unified organization of research and development, as suggested in item 3, will provide automatically a number of important and responsible positions which appropriately can be filled only by technically qualified, high-ranking

officers. Proper organizatory measures and a definite reform in personnel policy must go hand in hand, and only both together can secure the expected results.

There are also far too few competent civilian technical employees in the Air Force. Those now available are often working under the direct supervision of officers who have insufficient technical qualifications to direct their activities properly. Under no circumstances should a highly technical job carrying responsibility and authority be filled by anyone except a fully qualified technical man. Actually, in the great majority of technical jobs, it is far more important that the incumbent be technically and administratively competent than that he be an officer.

6. Air Force field facilities for research and development are ill-equipped for the jobs they have to do. Much additional capital investment must be made in permanent facilities, particularly at remote stations, even to accomplish the minimum job for which each location is uniquely fitted. The Air Force urgently needs new facilities to meet the challenge of the coming era of supersonic flight. The construction of new facilities should be initiated as part of an over-all Department of Defense plan which re-evaluates the existing facilities and insures adequate and continuing support to those which are found essential, but does not cause waste of money and personnel by arbitrarily prolonging the life of obsolete equipment.

7. The Air Force should make fuller use of the technical talent and facilities possessed by the industries and the universities of the country. A small recurring investment in the support of fundamental scientific investigations would secure for the Air Force the enthusiastic interest of the foremost scientists of the country; such men are today being substantially assisted mainly by the Office of Naval Research and by the Atomic Energy Commission. The Air Force is clearly faced by problems requiring fundamental scientific investigations; the best results in such work can be secured by direct contact between an Office of Air Research and scientists.

Further, Air Force contracts with industry frequently are restricted to the development of one component of a complicated system, based mostly on the results of operational staff studies. However brilliant such staff studies may be from the operational standpoint, they will probably fail to take full account of the intricate technical possibilities which largely guide the evolu-

tion of military requirements. They should therefore be supplemented by enlisting the aid of industrial concerns and research institutions in the work of establishing the optimum characteristics of the entire weapon system, thus properly balancing operational requirements and technical possibilities. The best component design would then develop organically from such a procedure.

Finally, the Air Force should most seriously consider and undertake the operation of facilities required for research and development work by industrial contractors and non-profit organizations.

8. In Air Force Regulation 80-4, there has already been set forth an official policy consistent with most of the changes recommended above, so far as research is concerned. Immediate steps should be taken to implement AFR 80-4, and a similar regulation stating Air Force policies concerning development should be issued and implemented.

It has not been possible in this short letter to do more than mention the principal findings of the special Committee. I hope that you will be able to look over the detailed report, which documents and extends the points above. You will observe that only general answers are offered to two of your questions: first, regarding a master plan for facilities development; and second, regarding a method for insuring the most effective interaction between technical development, on the one hand, and plans and operations, on the other. The preparation of a long-range facilities plan requires more time than was available to the special Committee. However, the Scientific Advisory Board has set up a Facilities Committee which is studying this problem and will assist in the formulation of a functional plan to integrate existing and future facilities. The Committee believes that the answer to the second question will quickly evolve if USAF research and development activities are brought together and endowed with responsibilities and prestige, so that the man in charge of research and development is given a direct voice in the important top-level deliberations of the Air Force. One important aspect of this problem is the preparation of a report which gives estimates of the time-phasing of research and development objectives and their introduction into operational use. This can be accomplished only by a cooperative effort between operational and scientific planners. The Scientific Advisory Board could be of assistance in such work.

One important fact must be kept in mind. Research and development activities cannot be brought to full effectiveness without making corresponding sacrifices elsewhere in the Air Force. A decision to correct some

of the deficiencies in the present research and development situation will be valueless unless it is implemented in terms of competent men, money, and effort, and such men, money, and effort must come from a fixed, possibly even a declining, total Air Force allocation. It is my feeling, and that of the Committee, that the effectiveness of research and development is so uniquely important to the continued supremacy of the Air Force and the continued security of the nation that the necessary sacrifices must be made. Steps should be taken to insure that the process of successive cuts and economy measures within the Air Force do not form a growing avalanche which hits research and development with its maximum impulse, destroying essential agencies and projects of this vital part of the Air Force organization. If you are persuaded of this, please consider the attached report as an attempt to outline some of the steps which might be taken.

Respectfully yours,

Theodore von Karman
Chairman,
Scientific Advisory Board

The Committee:

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James B. Fisk
Carl F. J. Overhage
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CONCLUSIONS AND RECOMMENDATIONS

PRESENT USAF RESEARCH AND DEVELOPMENT ORGANIZATION AND PROCEDURES

The Committee is of the opinion that a highly technical Service such as the Air Force should prepare itself to take a more competent role than it is now taking in guiding the solution of the technical problems connected with its weapons and techniques.

GENERAL POLICIES FOR RESEARCH AND DEVELOPMENT

The Air Force should now put a major effort into implementing the policies for research that are stated in AFR 80-4.

A new Air Force Regulation, similar to AFR 80-4 but dealing with policies governing development work in the Air Force, should be prepared, issued, and put into full effect.

The most important single factor in securing effective Air Force research and development is continuity of support, both policy support from the top command and budgetary support from year to year. Such support, though well worth giving, can be given only at the expense of other Air Force activities.

THE ORGANIZATION OF RESEARCH AND DEVELOPMENT IN THE AIR FORCE

Revision of the organizational structure will not, in itself, correct the deficiencies in the present conduct of research and development, but will make it easier to introduce the necessary improvements in personnel, program, and budget policy.

Control of research and development affairs by a single agency is urgently necessary to end the confusion brought about by scattered responsibility.

Intelligent direction of the over-all effort in research and development can be most effectively established in a Research and Development Command.

The establishment of a Deputy Chief of Staff for Research and Development is suggested as one possible means of insuring sufficient impact of research and development on long-term planning for the Air Force as a whole, and providing adequate staff support for Air Force research and

The introduction of personnel and budget policies and organizational patterns suitable for the successful pursuit of research and development can be best accomplished in a Research and Development Command that is separate from and independent of the Materiel Command.

With few exceptions, all current and future research and development operations of the Air Force should be controlled by the Research and Development Command which should include systems groups charged with over-all responsibility for the development of complete weapons systems.

Integral with the Research and Development Command, the Office of Air Research should have charge of the Air Force program of contracts for basic research, and of the proposed fellowship program. It should also establish the link between research activities in the Air Force and teaching and research in the Air Institute of Technology.

The weapons systems that result from research and development effort should be tactically evaluated by agencies outside the Research and Development Command. Their findings should be used in formulating operational plans and requirements, and in guiding further research. Closer understanding between operational and research commands must be achieved by mutual education.

Close liaison at all levels must be achieved between the Research and Development Command and the Materiel Command so that there can be strong and continuous interaction between production problems and development effort.

THE BUDGET FOR RESEARCH AND DEVELOPMENT

Budgets should be prepared and accounts be established so that not only the direct costs, but the total costs of the Air Force research and development program can be determined and presented. A similar consolidation of personnel ceilings, both civilian and military, should be effected.

Initial research and development budget estimates and personnel ceilings should be prepared by the Air Force research and development organization. They should include all costs and personnel for both direct and indirect activities, and each research and development installation should have a voice in the budget applicable to that installation. Direct representation from the research and development organization should be provided on the Air Force Budget Advisory Committee.

The Comptroller of the Air Force and the research and development organization should collaborate closely to develop an accounting system consistent with Air Force research and development requirements. A committee including representatives of the three Services should be established under the Secretary of Defense to work with the new Comptroller of

Defense on the broader aspects of ac[illegible]ti[illegible]ystems specifically for th research and development work of all three Departments.

Multiple budget and accounting [illegible] while intended to provid more information than a single system, ar[illegible] inflexible and complex t provide a good basis for management decisions. A single improved budg and accounting system is recommended.

The total budget for research and development must be stabilized t ensure continuity of support to the entire program, including contract with industry. A steady increase in the relativ[illegible] expenditure for technica purposes should be expected as a result o[illegible] ances in the technology o air warfare.

RESEARCH AND DEVELOPMENT PERSONNEL

Immediate steps must be taken to husband present Air Force resources of technical manpower, to use presently qualified personnel to maximum effect, and above all to institute policies which will strengthen the technical manpower of the Air Force.

The Air Force should increase allotments of technical personnel for research and development. This can only be done by reducing the force-in-being to enhance the effectiveness of the Air Force of the future, but in the opinion of the Committee such a sacrifice is necessary and fully justified.

High-priority action should be taken to improve the utilization of military technical personnel. A Directorate of Technical Personnel in the office of the Deputy Chief of Staff, Personnel, is suggested as a possible interim measure, pending a further study of the problem in connection with the establishment of a Research and Development Command.

The professional status of technical officers must be among the highest in the Air Force, and this must be made abundantly clear by promotion in technical work as rapidly as in other activities, by opportunity for promotion to general officer rank in and for technical work, and by recognition and decoration for excellence in such work. The Committee recommends that the Air Force consider establishing a decoration ranking with the Distinguished Flying Cross to reward outstanding individual achievement in research and development.

The Air Force should make an inventory of technical officers, institute a career guidance plan for such officers, step up the scale of the postgraduate training program, and take immediate steps to augment the supply of officers with advanced technical training.

The key to attracting and retaining highly competent civilian technical personnel lies in providing openings for important management jobs,

stability and significance in Air Force research and development programs, and additional emphasis on opportunities for professional improvement.

Successful implementation of Air Force Regulation 80-4 will improve the morale of professional employees and will in large measure solve the problems of recruiting technically qualified civilians. There is presently an urgent need for improved practices which can be instituted under the existing legal framework.

FACILITIES FOR RESEARCH AND DEVELOPMENT

The present haphazard pattern of Air Force research and development installations must be organized into a carefully planned and implemented system of modern facilities.

To maintain the leadership of the Air Force in providing for national security, it is essential that the Air Force take the initiative in presenting to the nation a plan for research and development facilities that is realistic in budget requirements, constructive in inter-Service collaboration, and attractive to top-grade technical personnel.

The Research and Development Command should be responsible for planning facilities in terms of the anticipated technical requirements of the research and development program, with due regard for flexibility of design, for maximum utilization of existing facilities, and for proper scheduling of new construction.

Where facilities must be established in remote and isolated regions, they should be limited to the minimum equipment and personnel consistent with safe and effective operation. Where possible, all supporting activities should be located at a base facility in an urban center, and technical work at the remote station should be performed by task forces moved there for short periods.

Contract operation of government facilities has been successful in providing competent civilian staffs for research and development work, and should be adopted by the Air Force as circumstances permit. Elaborate facilities provided for manufacturers engaged in development work should be operated by a non-competitive organization, and be accessible to all contractors.

Muroc Air Force Base is a unique facility of great importance to the Air Force. It should be properly implemented on a permanent basis as a top-priority project.

An Armament Center is urgently needed by the Air Force. However, the desirability of locating this Center at Muroc AFB rather than at Eglin AFB should be more carefully evaluated, before proceeding with its implementation.

Strong top-level support has greatly accelerated the process of securing the necessary enabling legislation for the Air Engineering Development Center. Continuation of this support should insure the final overcoming of legislative and budgetary problems, thus finally making possible the urgently needed implementation of the AEDC.

The Torrance Ramjet Test Facility or another suitable ramjet test facility should be promptly implemented to meet specific needs of the Air Force guided missiles program.

Based on the results of a comprehensive study, the Air Force should move with all speed to implement on a permanent basis the joint operation either of the Holloman-White Sands complex or of the Inyokern-Point Mugu combination, in order to provide an adequate facility for testing guided missiles of short and intermediate range. The study should also determine the additional facilities for experimental tests which may be eventually required.

OPERATING PROCEDURES FOR RESEARCH AND DEVELOPMENT

Within the Air Force, the role of systems engineering should be substantially strengthened, and systems projects should be attacked on a "task-force" basis by teams of systems and components specialists organized on a semi-permanent basis.

The Air Force should enlist more general and more effective industry cooperation by contracting not merely for components, but also for the solution of system and sub-system problems.

The Air Force organization responsible for research and development should have its own contracting group, separate from the group responsible for supply contracts, in recognition of the fact that procedures and regulations best adapted to handling research and development contracts differ importantly from those appropriate to production contracts.

The Air Force organization charged with research and development should have its own supply and purchasing group which should operate with a maximum degree of flexibility to meet the unpredictable needs of research and development work.

The Air Force should study its system of design competition, with a view to making it more effective as a tool for developing the best possible new aircraft, by preserving the values of competition while reimbursing manufacturers for their design costs, thus making it possible to embody in new aircraft the advanced ideas of all competitors.

Adequate budgetary support should be provided to make possible a consistent USAF program of study contracts, design competitions, and devel-

opment contracts. This will permit the aircraft industry to stabilize research, design, and engineering staffs, thereby assuring their continued effectiveness and availability to the Air Force.

FUNDAMENTAL RESEARCH AND THE AIR FORCE

A small fraction—say two or three per cent—of the research and development budget of the Air Force should be consistently assigned for the purpose of making contracts with educational institutions for fundamental research in broad general fields on problems which, without being directed toward definite goals or applications, are of potential interest to the Air Force.

The Air Force should seek legislation empowering it to award a modest number of predoctoral and postdoctoral fellowships to highly qualified students.

The Air Institute of Technology should be made into a graduate school of engineering ranking with the best civilian schools in this category, and having specific objectives derived from the needs of the Air Force.

I. ROLE OF THE PRESENT COMMITTEE

Four years ago, a Scientific Advisory Group appointed by General of the Air Force H. H. Arnold and headed by Dr. Theodore von Karman made a study of present and future technical problems of interest to the Air Force. The principal object of this study was to point out the probable goals of Air Force research and development, although it also addressed itself to the policy changes and organizational steps required to achieve those goals most effectively, promptly, and economically.

The terms of reference of the present Committee are rather more restricted. In the belief that the work of the Scientific Advisory Group, as modified by later events, has successfully defined the **technical goals** of Air Force research and development, the present Committee has concerned itself, at the request of the Chief of Staff, with the **means for accomplishing** research and development within the Air Force. Tab A sets forth the membership of the present Committee, the questions that have been directed to it, and an outline of the investigations which the Committee conducted in the course of its work.

Presumably, the present Committee would not have been appointed if there had not been a considered opinion that the research and development accomplishment of the Air Force could be improved. From the very beginning of its studies, the Committee found that this opinion is widespread in the Air Force; actually, the Committee interviewed no individual who was not to some extent dissatisfied with the present situation. The objective findings of the Committee itself indicate many areas in which the ability of the Air Force to conduct research and development can be substantially improved. This report sets forth the Committee's recommendations.

II. GENERAL REMARKS ON RESEARCH AND DEVELOPMENT

A. THE IMPORTANCE OF RESEARCH AND DEVELOPMENT

The Air Force has a highly technical job to do. Its weapons are new and must continually reflect the advances brought about by modern technological developments. The effectiveness of air weapons is highly sensitive to differences in technical quality. In 1944, for example, the German Air Force possessed in the jet fighter a weapon which, properly used in sufficient quantity, could have inflicted catastrophic damage on the strategic bombardment force with which the United States was then defeating Germany. This did not occur, largely because of a mistaken German policy decision; but the two or three years by which German jet engine development led our own could have been extremely important, and conceivably could have been decisive.

Thus the Air Force is not a static force, and cannot afford to be. It must introduce into its fighting units, as rapidly as possible, the most advanced weapons that current technology can develop. Only by doing so can it maintain its state of readiness and effectiveness.

The present Chief of Staff, General Hoyt S. Vandenberg, has clearly recognized and stated the vital necessity of maintaining a proper balance between the Air Force of today and the research and development which will bring into being the Air Force of tomorrow. Writing in the July 1949 issue of the *Army Information Digest*, he said:

> "There are many balances which we must achieve within the Air Force itself. We must balance our investment against the possibilities of war today and the possibilities of war five or ten years from today. We must not fatally weaken ourselves today in order to be strong tomorrow. On the other hand, we must not mortgage our future by neglecting research and development in order to gain the temporary advantage of a great number of today's weapons."

The importance to our national security and to our national policy of the continued readiness of the Air Force is widely appreciated, but may bear repetition here. Any war which we can now foresee will be an inter-continental war, and we must presume that in such a conflict the Air Force would play the major role, since naval blockade would be ineffective and land invasion against an unweakened enemy would be hazardous in the extreme. But air power can strike at the heartland of the enemy from the

very beginning of a future war; and its effectiveness in destroying the will and ability to resist has been amply demonstrated in Germany and in Japan.

Even more important, at the present moment, is the deterrent effect of our air power upon the Russians. Russian conduct has suggested that their agreed policy is one of sustained hostility to the western world, specifically to the United States. It has suggested that Russia would not be unwilling to provoke armed conflict, if her chance of winning were thought to be good. On every recent occasion in which armed conflict has seemed to be the last resort, Russia has yielded. Presumably this means that she is impressed by our existing and our potential arms; and what impresses Russia can scarcely fail to be our Air Force and its atomic weapons.

To maintain this impressive role during the years of negotiation and diplomacy to come, the Air Force must retain its present qualitative superiority. Since it deals in a rapidly changing art, it must change, too. And the changes it must make will come out of research and development work, the effectiveness of which is the subject of this report.

B. WHAT ARE THE FUNCTIONS OF RESEARCH AND DEVELOPMENT?

It will be useful in later discussion to define the functions of research and development. Broadly speaking, Air Force research and development is charged with devising and designing new techniques and instrumentalities which will increase the combat effectiveness of the Air Force. The work of research and development is accomplished in steps which, although they frequently merge with one another or overlap, can be described as follows:

Fundamental research comprises investigations carried on for the purpose of increasing man's knowledge and understanding of the natural world. Since the unknown is being sought in fundamental research, what specifically will be found is equally unknown. Almost always, the results of fundamental research are useful for one practical purpose or another, yet prediction of such usefulness cannot be made in terms of specific application, but only—and then with difficulty—in terms of **fields** of application. Major discoveries of fundamental significance can almost always be traced back to their roots in a fundamental investigation.

Applied Research is the term used to describe the systematic survey of a field of fundamental research in order to discern and support application to the design of specific devices.

Initial development is the term used hereafter to describe the first step in realizing a technique or device which makes practical use of an idea or discovery that has resulted from research. Little attention is paid at this stage to the operational suitability, from every standpoint, of the device or technique to be developed; effort is principally devoted to learning what can be done with the idea or discovery.

Engineering development refers to the refinement and the practical improvement of the device developed in the prior stage. Applied research and initial development having demonstrated that useful results can be secured, attention is now given to the detailed design of a practical and useful device which can fill a specified need.

Development during production normally occurs when a device is manufactured in quantity. Production itself is not a part of the research and development picture, but design changes will usually result from the fact that the device is being manufactured. There will thus be an effect on design produced by the production process.

Development resulting from service use almost always occurs. When a new device is put into the hands of those who must use it in operations, unexpected weaknesses and deficiencies are likely to be uncovered. Such discoveries will lead to design changes which must, in general, be made either by those responsible for the engineering design, or else by others who work in close cooperation with them. Operational use of the device will also frequently point up the necessity for design changes resulting from changes in the tactical or strategic situation.

At some stage during the development of a new device, a decision may be reached that the item will constitute an important improvement over similar items in current use, and that some quantity should be manufactured for operational use. The point at which this decision is taken varies widely from case to case, because it depends importantly on many factors which vary widely with different situations. Prior to a decision on production, those who are concerned with development of any given item must take into account the problem of production, since the item must be produced before it can be used. In aircraft development, production problems are generally considered very early in the development process. After a decision to produce has been made, the designs, data, and techniques which have resulted from development must be transferred to the manufacturing organization, and the development engineers must for a time work closely with the production engineers.

Plans for future operations should always take into full account the potentialities of future weapons and techniques which are expected to be available from research and development. Further, the general program of research and development, and the relative priority of projects within that program, should be related to the plans, strategies, and operating techniques which are current in the Air Force, or planned for the future. Liaison between plans and operations and research and development is therefore essential.

While a new weapon or device is going through the successive development phases named above, its various models will be tested under conditions which approximate more and more closely those of actual field service. The following categories of tests can be distinguished:

Functional test of preliminary model. This test is associated with initial development, and is carried on by the scientists or engineers who are engaged in initial development. Its purpose is to verify the technical estimate of the performance of the device under the most favorable and carefully controlled circumstances. These tests may in themselves be very dangerous (e.g., structural and aerodynamic flight testing). However, in most cases no attempt is made to simulate all the practical rigors of service use.

Technical suitability test of production prototype. When a device is being prepared for production, it is customary to subject the model which results from engineering development to a series of tests designed to determine whether or not it meets technical requirements and to establish its performance under all conditions of temperature, altitude, vibration, etc., which might be encountered in operational use. Performance deficiencies uncovered by such testing are rectified by design changes.

Technical suitability test of production model. Once production is under way, tests like those described above are usually made on a production model, to ensure that performance has not been affected adversely by any changes made in going from prototype to production model.

Operational suitability test. When a new device begins to be available from production, it is tested in its intended service use, and evaluated not from a technical standpoint, but rather in terms of its operational suitability for its intended purpose. Such testing is performed in the Air Force by the Air Proving Ground Command. Design changes may result from these tests.

The preceding description of the steps in research and development, and the various tests associated with those steps, have assumed that what is being developed is a tangible physical device such as an airplane, an engine, or a missile. Increasingly in recent years, the Air Force has found itself involved in research activities which concern intangibles. Project SCOOP, a programming investigation of interest to the Comptroller, is one example; the study of aims and means of psychological warfare is another. There is no "production" which results from such investigations, and the usual language of military requirements specifications, and tests, is not useful for this class of work. It may not be too inaccurate to class all such work as falling into the categories of fundamental and applied research.

C. THE REQUIREMENTS FOR EFFECTIVE RESEARCH AND DEVELOPMENT

Although they are difficult to achieve, the basic requirements for effective Air Force research and development can be rather simply stated. In order to implement a sound research and development program, the Air Force must have:

1. Policies which are adapted to the special nature of the research and development task.
2. An organizational structure best fitted to accomplish the work.
3. Adequate funds, and a suitable budget and accounting structure.
4. Personnel of the highest technical competence, and personnel policies which will attract, retain, and use to best advantage such technical personnel.
5. Adequate facilities, adequately supported.
6. Operational procedures designed to promote internal efficiency and satisfactory relations with industry.

III. PRESENT USAF RESEARCH AND DEVELOPMENT ORGANIZATION AND PROCEDURES

A. PRESENT ORGANIZATION FOR RESEARCH AND DEVELOPMENT

A diagram of the existing USAF organization as it concerns research and development is shown in Tab B. The main operating function is concentrated in a Directorate of Research and Development which forms a part of the Air Materiel Command; this Directorate has Divisions for Engineering, Flight Test, and All-Weather Flying. Field development and testing facilities are maintained at exempted stations such as Muroc AFB, Kirtland AFB, Holloman AFB, Griffiss AFB, and so on.

Staff responsibility is centered in a Directorate of Research and Development under the Deputy Chief of Staff, Materiel. In addition, other staff agencies have an interest in research and development, and sometimes an explicit responsibility for such work in their special fields. Examples are the Director of Armament (under the Deputy Chief of Staff, Materiel), the Special Assistant for Atomic Energy (under the Deputy Chief of Staff, Operations), the Special Assistant for Guided Missiles (under the Deputy Chief of Staff, Operations), the Comptroller, and the Surgeon General, USAF. Tab B contains a statement of the research and development functions of these Staff agencies.

Budget preparation and approval, which so largely control the level of the research and development program, bring other agencies into the picture. Within the Air Force, the Comptroller and the Budget Advisory Committee are involved. The portion of the total Department of Defense budget on research and development that is for the Air Force and the distribution of emphasis within this portion are influenced by the Research and Development Board. The Bureau of the Budget must approve the resulting program, and finally the appropriation must be made by the Congress.

B. HOW IS AIR FORCE RESEARCH AND DEVELOPMENT NOW PERFORMED?

Research and development needed by the Air Force is accomplished partly by the USAF directly, and partly by other agencies which serve the

Air Force. The following is a somewhat oversimplified discussion of the typical division of effort between the USAF and the outside agencies which may be concerned.

Fundamental research is usually performed outside the Air Force. In such fields as aerodynamics, power plants, and structures, the National Advisory Committee for Aeronautics is the principal source of both fundamental and applied research. University laboratories also make important contributions, as do the larger industrial research laboratories. Fundamental work is usually performed for its own interest by such laboratories, rather than being done on Air Force contract.

Except in the field of electronics, where the Air Force maintains a fairly large and fairly competent staff, initial development is almost entirely accomplished for the Air Force by other agencies. Industries and universities perform most of this work, usually on a specific Air Force contract which requests and pays for the work that is to be done. The Air Force also relies on branches of the other Services—for example, the Ordnance Department of the Army—to perform initial development in special fields on its behalf and at its expense. The principal role of the Air Force in connection with initial development is to evaluate the relative priority of what is to be done, embodying such decisions in future budgets, and to serve as a clearing-house for information.

Engineering development of a device which is to be manufactured is principally a function of the industrial contractor who will have the manufacturing responsibility. However, this work is importantly controlled by technical specifications which are prepared by the Air Force. A large part of the effort of the Engineering Division of the Air Materiel Command goes into the preparation and the refinement of such specifications.

Development during production and development resulting from service use are usually accomplished by the manufacturer with assistance and advice from the Air Force.

It is in connection with testing that the Air Force now performs its major role. The functional testing of the preliminary model of a new device is ordinarily performed by the agency which has originated the device; as already remarked, this may be either the Air Force or an industrial or university contractor. When flight testing of the preliminary model of a new component is required, it is usually performed by the contractor, sometimes in aircraft supplied by the Air Force. If especially expensive facilities are needed, the Air Force ordinarily provides them. Such manufacturer may perform for his own information a technical preliminary test of a production prototype, such tests are performed by the Air Force in any case. Their primary purpose is to determine whether the production prototype meets the specifications which have been set up to apply to the device

in principle. Precisely the same remarks ... the technical suitability ... tested of the production model.

Operational suitability testing is the ... responsibility of the Air Force, and is in fact performed by an Air ... agency different from that responsible for research, development, ... ment.

It is clear that the Air Force differs ... from the Army and the Navy in the extent to which it performs for itself functions of research and development. The Army and the Navy ... research and development laboratories in which is performed an im... part of the total work for which funds are available. In the Air Force, ... the other hand, the work is very largely confined to the preparation ... specifications, contract administration, the "monitoring" of research ... development, preparation and defense of budgets which have to be ... carried in several different forms to several agencies, and technical assistance ... testing.

It is true that the fraction of research ... development funds applied to contract work is about the same in the Air Force ... as it is in the Air Force, and the overall budget is the same for the two ... organizations. However, the Navy has about three times as many persons engaged in research and development as the Air Force has, while the funds allocated to the Navy for research work done within the Navy establishment are relatively small in comparison with the total research and development budget. Thus the difference in attitude regarding research and development personnel cannot explain the great disparity in research ... concentrated within the Service as between the Air Force and the Navy. It concludes that Air Force research and development is presently ... unwarranted, and that its scope is much too narrow.

The number of technically competent ... now in the Air Force, both officers and civilians, is already ... even to perform the present limited technical undertakings. ... number of personnel is built up to remedy this defect, attention should be focused on the goal of increasing the technical competence of the Air Force.

It has already been mentioned that the Air Force actually maintains a research and development organization in the field of electronics. This appears to constitute an exception to the principle that the Air Force procures research and development from outside agencies. It becomes understandable, however, when one recalls that the Air Force inherited this organization and its personnel from the Signal Corps during the recent war.

The Committee is of the opinion that a highly technical Service such as the Air Force should prepare itself to take a more competent part than it is now taking in guarding the solution of the technical problems connected with its weapons and techniques.

IV. GENERAL POLICIES FOR RESEARCH AND DEVELOPMENT

A. INTRODUCTION

With respect to research, the Air Force has already enunciated in Air Force Regulation No. 80-4 (attached as Tab C) most of the basic policies which those experienced in research and development consider to be essential for making effective progress. The Committee found in its investigations, however, that actual practices in the Air Force differ substantially from those which are recommended in AFR 80-4. Further, a similar policy statement governing **development** has not yet been prepared and issued.

B. IMPLEMENTATION OF AFR 80-4

To be sure, AFR 80-4 was just published on 1 March 1949, and there has since been insufficient time for its full implementation. Unless a fully determined effort is made to put it into effect, however, it is likely to take its place with numerous past expressions of intent by the Air Force with regard to research and development, which have been sound in conception and in principle, but have never been carried through.

The basic reasons for the failure to carry out such good intentions concerning research and development are entirely understandable. The Air Force has been preoccupied ever since the war with a series of major, immediate problems which left no effort available for investment in research and development activities. The temptation to benefit the immediate, operating Air Force at the expense of the Air Force of the future will always be strong; for an investment of funds and effort in research and development, while it brings great dividends, does not bring them at once.

However, the present seems to be a uniquely important time for the Air Force to carry through a major effort to bring its research and development work to a satisfactory state. The regime of practical supersonic flight is being entered, and advances in control and guidance mechanisms promise to make the long-range, accurate guided missile a practical reality. All three Services in the Department of Defense are taking a keen interest in the development of guided missiles, and are supporting their interest by means of research and development work. The Committee understands that the Army has recently proposed to the Joint Chiefs of Staff that developmental and operational cognizance over ground-to-ground and ground-to-

air guided missiles be given to the Army. If this were to be done, it would transfer to the Army a large share of the future mission of the Air Force. Yet the Air Force will scarcely be in a position to claim for itself cognizance in such matters, unless its developmental achievements and its operational proficiency rank with or are superior to those of the other Services. Pre-eminence in any new field cannot be legislated or proclaimed, with any chance of success. It must be earned. It can be earned only by sound achievement in research and development.

The Air Force should now put a major effort into implementing the policies for research that are stated in AFR 80-4.

C. A NEW AIR FORCE REGULATION STATING POLICIES FOR DEVELOPMENT

As already noted, AFR 80-4 deals only with policies concerning Air Force research. A similar statement of policies governing development should be prepared and issued. In many respects, the latter statement can be parallel to AFR 80-4, but there will be detailed differences which arise from the difference in aims and methods between research and development.

So far as AFR 80-4 has so far been without substantial effect because it has not been implemented, so the proposed new regulation will be worthless unless its policies are carried out in day-to-day operations throughout the research and development organization.

A new Air Force Regulation, similar to AFR 80-4 but dealing with policies governing development work in the Air Force, should be prepared, issued, and put into full effect.

D. CONTINUITY OF SUPPORT FOR RESEARCH AND DEVELOPMENT

It must not be supposed that the present deficiencies in Air Force research and development which the Committee discusses in the balance of this report will yield all at once to a major attack along the lines set forth in AFR 80-4, and to be set forth in the proposed new regulation on development policies. A constant and consistent effort must be made to support research and development activities in general and in detail over the years to come.

One of the most important aspects of the support that research and development will need is the budgetary aspect. An effective program of research and development can be achieved only when its budgetary support is relatively stable from year to year, since an effective program must be

based on long-term plans, and most important projects take years to bring to successful completion. It is likely that total Air Force appropriations will fluctuate from year to year, so that stability in the research and development budget can be obtained only by causing other activities to absorb the fluctuations and deficiencies in funds.

This decision can be supported by the following reasoning: A reduced appropriation for the Air Force expresses the opinion of the Congress that war is not immediately likely. If war is not imminent, then the Air Force of the future is far more important than the force-in-being and should, if necessary, be supported at its expense. When war seems imminent, the reverse will be true; but at such a time funds will almost certainly cease to be the limitation on programs, being replaced in this role by manpower. Under these circumstances, the force-in-being should be given priority on manpower.

In any case, it is clear that the support which Air Force research and development presently needs and must have before it becomes fully effective can be given only at the expense of other Air Force activities. It is neither cheap nor easy to follow the policies outlined in AFR 80-4 and detailed in this report; but in the opinion of the Committee, it is vital to the continued success of the Air Force to do so.

The most important single factor in securing effective Air Force research and development is continuity of support, both policy support from the top command and budgetary support from year to year. Such support, though well worth giving, can be given only at the expense of other Air Force activities.

V. THE ORGANIZATION OF RESEARCH AND DEVELOPMENT IN THE AIR FORCE

A. INTRODUCTION

The difficulties experienced by the Air Force in the execution of its research and development program stem from many causes. One of these is the structure of the present organization, and the Committee believes it should be changed. In our discussions with Air Force officers we have found much interest in revising the organization for research and development. In fact, we fear that too much faith may be placed in the beneficial effects of reorganization. It is by no means a cure-all. It does not, in itself, provide adequate facilities. Nor does it solve the most important problem of all, to secure better personnel—higher technical competence, improved morale, greater personal effectiveness. But good organization is an important preliminary step. It eliminates conflicts by dividing the program into logical functions, and makes it possible to establish administrative and budgetary policies that will attract and retain personnel of the highest caliber.

Revision of the organizational structure will not, in itself, correct the deficiencies in the present conduct of research and development, but will make it easier to introduce the necessary improvements in personnel, program, and budget policy.

B. CONTROL BY A SINGLE AUTHORITY

In the course of its review of the policies governing Air Force research and development, the Committee has found much confusion of purpose between different agencies among whom the responsibility for technical advancement is currently divided. At the staff level, research and development programs are nominally controlled by the Directorates of Research and Development under the Deputy Chief of Staff, Materiel. In the field of aircraft armament, independent authority for research and development is vested in the Directorate of Armament. In the fields of atomic energy, guided missiles, and communications, important responsibilities are assigned to agencies under the Deputy Chief of Staff, Operations. In theory, these responsibilities may not specifically include research and development, but in actual practice the coordination with the Directorate of

Research and Development has not always been effective. In fields not directly related to materiel, important research programs are also sponsored by the Directorate of Statistical Services under the Comptroller, and by the Surgeon General. While some research is appropriate to each of these directorates or offices, there is a diffuseness, a lack of a modern professional research organization, which leads to the treatment of each new problem on an **ad hoc** basis, and certainly interferes with the planning and execution of a strong Air Force program.

More serious perhaps than the overlap in authority between different staff agencies is the division of authority between staff and command. This latter problem is not unique to Air Force research and development. It is one of the most difficult and challenging problems in all phases of the management of large organizations. In the materiel activities of the Air Force, the problem arises in a particularly acute form because the staff agency supervises only a single command, so that one of the normal staff functions, coordination of separate commands, is altogether missing. Moreover, the Air Materiel Command has a large and populous headquarters organization of its own at Wright-Patterson AFB, and in many instances it is very difficult to arrive at a clear distinction between the responsibilities of the Directorate of Research and Development, Headquarters Air Materiel Command, and the Directorate of Research and Development, Headquarters U. S. Air Force.

The desirability of avoiding such conflicts by consolidating responsibilities under the control of a single agency is generally recognized. Problems of facilities planning, of realistic budgets, of adequate treatment of technical people in technical jobs, and of infusion of new scientific ideas and developments into operational plans and operational thinking, we believe, can be solved only if the research and development job has a clear and single path to the top of the organization, a clear and single path back, and a single head.

Control of research and development affairs by a single agency is urgently necessary to end the confusion brought about by scattered responsibility.

C. A COMMAND FOR RESEARCH AND DEVELOPMENT

While there are several alternative schemes by which research and development responsibilities could be brought together under a single directing authority, the Committee prefers the suggestion that this direction be exercised by a Command rather than by the Air Staff. It is one of the peculiar characteristics of research and development work that it responds

badly to direction by remote authority. A strong and effective manager of a research program cannot long separate himself from direct contact with the operations of his laboratories. When isolated in a remote office, he rapidly loses his grasp of new currents of technical thought on which he is dependent for sound judgment in program decisions.

Whenever the attempt is made to control research and development by a staff agency, the director of that agency finds it necessary to surround himself with specialists in various phases of the program. In the course of time, the staff organization grows into a small replica of the actual operating group. Since the program must constantly be adjusted and modified in the light of new findings, control can be exercised only by detailed directives based on close, continuous, and detailed supervision by the staff organization. This violates the fundamental precept that a staff agency should limit its exercise of authority to broad directives. The Committee, therefore, believes that it is inherently unsound to attempt staff control of research and development, and recommends the establishment of a Research and Development Command for this purpose.

The Committee makes this observation without implying any opinion regarding the relative qualifications of the military and civilian technical personnel now assigned to the research and development activities at the Air Materiel Command and in the Air Staff.

Intelligent direction of the over-all effort in research and development can be most effectively established in a Research and Development Command.

D. THE HEADQUARTERS STAFF AGENCY

In the Committee's opinion, there are important functions in long-term planning for the Air Force as a whole and in the management of research and development that must be performed by a headquarters staff agency for research and development.

Long-term, over-all planning for the Air Force as a whole can be carried on effectively only by the combined efforts of the major staff elements concerned on a co-equal basis. Such planning by top-level staff elements must of necessity be based upon the employment of newly conceived equipment, since the development of just one new weapon can completely alter a given concept of waging war. The representation of research and development at top staff levels is essential to the accomplishment of the Air Force mission in National Defense. It will insure on the one hand the best technical opinion on development possibilities and prospects in the determination of war plans and operating policies, and will facilitate on the other hand the effective programming and planning of research and

development activities and facilities to meet the requirements of the Air Force of the future. Only by this reciprocal interaction of research and development on plans and of plans on research and development can the Air Force attain the progress in weapons and strategy essential to the national security.

In the management of research and development, the headquarters staff agency must maintain close liaison with the many other Air Force and Government activities that are involved in the planning and execution of research, and in the evaluation and use of the results. In the day-to-day effort that is required to maintain an easy and rapid flow of essential information to and from the Research and Development Command, the staff agency can make or break the success of the entire program. With good support from the staff, the head of the Research and Development Command will be free to devote himself to those tasks that only he can perform: the top direction of the actual research and development activities, and consultation on these matters at the highest Air Force and government levels.

An effective way of performing these important functions must be found when a Research and Development Command is established. It appears that the simplest solution would be an increase in the number of Air Staff sections by the appointment of a Deputy Chief of Staff for Research and Development. Such a move would correspond with the organizational pattern and relationship existing in the Department of Defense between the Joint Chiefs of Staff and the Research and Development Board.

It seems to the Committee that confusion would be avoided, and a qualified individual more easily obtained, if the proposed Deputy Chief of Staff were also the head of the Research and Development Command. It should be mentioned too that the establishment of a Deputy Chief of Staff for Research and Development would most effectively demonstrate to legislative bodies and to the entire scientific world the importance and prestige which the Air Force places on its research and development activities. Of course, it is possible that other equivalent and workable solutions to this problem might be found, such as—for example—the constant participation of the Commanding General of the Research and Development Command in regular top-level staff meetings.

The performance of the primary duties which this report contemplates for the head of the Research and Development Command involves an important geographical problem: the command may not be located in Washington, where the head of the command is frequently required for consultation. The Committee does not underrate the difficulty of performing a job in two locations. Nevertheless, it seems sounder to face these

difficulties and attempt to solve them than to risk the confusion of divided authority which will inevitably occur when the staff in Washington assumes functions that properly belong to the command. The obstacles inherent in geographical separation can be reduced by the appointment of capable deputies and by the full exploitation of modern techniques of communication.

The establishment of a Deputy Chief of Staff for Research and Development is suggested as one possible means of insuring sufficient impact of research and development on long-term planning for the Air Force as a whole, and providing adequate staff support for Air Force research and development activities.

E. SEPARATE COMMANDS FOR RESEARCH AND DEVELOPMENT, AND FOR MATERIEL OR LOGISTICS

The entire complex of activities: fundamental research (new knowledge), applied research and initial development (the first approach to a specific end), engineering (for a tactically useful version), procurement, quality control, testing to specifications, technical evaluation, supply, maintenance, industrial planning and mobilization—are presently considered in the Air Force under one heading, **Materiel.**

Research and initial development differ both in magnitude and in kind from other materiel activities. For fundamental research, "Requirements" can be stated only vaguely, if at all. In important new areas, as in the Human Resources Program, the objectives are non-technical. The framework of traditional military organization does not provide the proper environment for research, nor does it provide for the rapid exploitation of ideas to a "breadboard" or prototype stage against a background of systems planning. The methods and procedures that have proven workable for the expenditure of large sums of money for USAF equipment, involving competitive bids, close "monitoring," and careful checking against specifications—these methods and procedures are inappropriate for research and for most of initial development. This is not to say that problems and objectives cannot be formulated in these areas, nor that it is unnecessary to know how funds are being spent. It is to say that experience has shown research and most initial development activities to flourish where freedom of inquiry and flexibility of program are provided.

The Committee believes that a distinct separation of these activities from the much more voluminous remaining activities of materiel is necessary. A sharp fixed boundary between the activities contemplated for the Research and Development Command and those of the Materiel—or Logis-

tics—Command cannot and should not be drawn. Some overlap is desirable to provide continuity between experimental and production activities. The responsibility of the Research and Development Command would usually extend through the construction and testing of experimental systems. The Logistics Command would take on the production responsibilities as soon as a decision has been reached to procure equipment for use by the operational commands. The activities assigned to the Research and Development Command should have an essentially independent status, a budget independent of procurement, personnel and personnel policies consistent with the job, and a single responsible head.

The introduction of personnel and budget policies and organizational patterns suitable for the successful pursuit of research and development can be best accomplished in a Research and Development Command that is separate from and independent of the Materiel Command.

F. THE SCOPE OF THE RESEARCH AND DEVELOPMENT COMMAND

The activities visualized by the Committee in the new Research and Development Command are at the present time distributed throughout the Air Force, with a heavy concentration in the Engineering Division of the Air Materiel Command. The preparation of a specific and complete list of the agencies, including Air Force Base facilities, that should properly be absorbed by the new Command calls for more detailed knowledge than this Committee has been able to acquire during its brief study. There is, however, an important principle that has been found successful in similar undertakings elsewhere, and in organizing the separate existing agencies into a new and independent command it should be followed. This is the division of the total effort in terms of broad functional concepts: research, components development, and systems development.

The last of these requires particular emphasis, because of the many new difficulties that arise when newly developed components must be assembled into successful weapons systems. It is of the utmost importance to have a clear and unambiguous assignment of the responsibility for the over-all performance of the entire new system.

Research in non-technical fields, with objectives not directly concerned with materiel, is a rather new thing in the Air Force. In the view of the Committee, this type of research, including for example the Human Resources Program, should become a part of the Research and Development Command, because this will ensure the earliest effective application of this work to the techniques planned for future warfare. For at least an initial

period of several years, the growth of this important activity may
healthier if this effort is organized into a separate division of the r
command, subject only to the over-all direction of the head of the co
mand. However, all possible encouragement should be given to inform
and frequent contacts between scientists working in this new field and c
neers concerned with weapons systems development.

Other features of the Research and Development Command will rea
suggest themselves as the detailed planning stage is approached, and sho
in large part be left to the discretion of the person charged with the co
mand responsibility.

With few exceptions, all current and future research and development operations of the Air Force should be controlled by the Research and Development Command which should include systems groups charged with over-all responsibility for the development of complete weapons systems.

G. THE OFFICE OF AIR RESEARCH

In establishing the Office of Air Research, the Air Force has taken
important step toward the ultimate strengthening of its research and dev
opment program, although some modification of the present concept w
be necessary before the Office can become really effective.

The Office of Air Research has been directed to conduct research o
preliminary nature, and to review research and development contrac
programs, and budget estimates. These important advisory functions
quire personnel of high technical ability and broad experience in resear
and development. The number of persons of this caliber is necessarily sma
and they will be more interested in assuming direct technical responsibili
as directors or principal scientists than in filling the advisory positio
now contemplated for the P-9 civilians of the Office of Air Research.

The Committee therefore believes that the Office of Air Resear
should become an integral part of the proposed Research and Develo
ment Command, and that the Command's technical experts, or at le
those who are centrally located, should also serve in the Office of A
Research. This plan would give the Office of Air Research an organ
strength and vital position in Air Force research and development whi
it does not now have.

The effectiveness of the Office of Air Research will be further broa
ened upon implementation of the recommended support of fundamen
research, both by contracts to universities and by fellowship awards. T
logical authority for supervising this important new phase of the Air For

program is the Office of Air Research. One of the essential contributions of this arrangement to Air Force progress will be the close and continuous communication established between the Air Force technical personnel and the leaders in academic research.

The Air Institute of Technology provides a similar opportunity to broaden the activities of the research and development staff, and to apply their unique experience to the training of future Air Force scientists and engineers. The Office of Air Research should play a major role in developing the Air Institute of Technology into an outstanding institution, and in planning the strongest possible combination of this institution with the technical staff of the Research and Development Command.

Altogether, the Committee has been impressed with the unique opportunity that will exist here to achieve a highly successful integration of specialized research, advanced instruction, and contract administration. The Air Force is a young organization, and its freedom from the restraints of tradition place it in an ideal position to take advantage of this opportunity.

Integral with the Research and Development Command, the Office of Air Research should have charge of the Air Force program of contracts for basic research, and of the proposed fellowship program. It should also establish the link between research activities in the Air Force and teaching and research in the Air Institute of Technology.

H. EVALUATION AND REQUIREMENTS

The problems of interaction between plans, requirements, research and development, evaluation, operations, and back to new requirements have been a source of concern to the Air Force for some time. The successful integration of advanced thought on weapons systems into the formulation of operational plans is a difficult and challenging task under the most favorable of circumstances. The diffuse and ambiguous assignment of research and development responsibility in the past has greatly complicated this task. The Committee believes that the reorganization of research and development into a separate command under a single responsible head will reduce these difficulties. Soon after the establishment of such a command, it will be clear that this is the source of the most competent advice on new developments, and also the authority for the most effective action on new requirements.

The Committee has given much thought to the tactical evaluation of new weapons systems, as contrasted with the technical testing performed

by the Research and Development Command. Although the technical understanding of such new systems is most advanced in the scientists and engineers who developed them, the Committee believes it would be a grave and fundamental mistake to assign the tactical evaluation function to the research and Development Command. The true, ultimate value of a weapon will be proven only in combat use. A tactical evaluation should consciously approach such use. This means that the weapon must be employed by operational officers and airmen, suitably trained in its use. Technical experts cannot simulate operations of that type, nor can they be expected to be entirely unbiased with respect to their own products.

There has been frequent difficulty in the past from mutual intolerance between research people and their customers in operational commands. Only time and education can cure this trouble. As the decisive importance of the continuous development of new weapons systems becomes more apparent, and as the educational background of Air Force personnel improves, the understanding between the development and operations will steadily improve. More frequent contact between research and operations groups can accelerate this process.

The weapons systems that result from research and development effort should be tactically evaluated by agencies outside the Research and Development Command. Their findings should be used in formulating operational plans and requirements, and in guiding further research. Closer understanding between operational and research commands must be achieved by mutual education.

I. LIAISON WITH PRODUCTION ACTIVITIES

In advocating a separation of research and development functions from the procurement and maintenance activities of the Air Materiel Command, the Committee has been fully aware of the importance of close and continuous contact between these two agencies. Production and mobilization aspects are essential parts of each development program. They must be given full attention in order to keep to a minimum the time required to develop new equipment. In producing complex new weapons, especially aircraft, there is a long period in which production is experimental in nature, and in which the closest collaboration with the development laboratory must be maintained. Difficulties encountered in the production and use of new equipment must be immediately fed back into the development effort. The importance of this collaboration as a basic requirement for successful mobilization must be always in the minds of those responsible

for the two commands, and they must be particularly eager to encourage good relations at the working level between development, procurement, manufacture, and maintenance.

Difficulties in this particular liaison problem may demand increased attention after the separation of research and development from the Air Materiel Command. However, the problem is well recognized, and industrial experience has shown that it can be solved by enlightened management effort. It is far less formidable than the danger of crippling research and development in competition with the urgent production problems which must always be the first concern of a command that is responsible for procurement and mobilization, as well as research and development.

Separation of experimental and production functions also implies that industry will have to deal with two separate Air Force commands. This circumstance may appear troublesome at first sight. Actually it will clear up an existing situation that is extremely confusing. Industry already deals with two sets of people from the Air Materiel Command: Research and Development, and Procurement and Industrial Planning. Although these operate under the same command, liaison between them has at times been poor. This has been less disturbing to manufacturers than the contract and accounting complications that arise when research and development work is carried on under procurement contracts. The Committee believes that the aircraft industry would respond favorably to a clear-cut separation of the contractual arrangements covering the research and development phase of their efforts from the straight procurement contracts.

Close liaison at all levels must be achieved between the Research and Development Command and the Materiel Command so that there can be strong and continuous interaction between production problems and development effort.

VI. THE BUDGET FOR RESEARCH AND DEVELOPMENT

A CONSOLIDATION OF FISCAL AND PERSONNEL DATA

From the information available, it appears that the funds for carrying out and supporting research and development in the Air Force come from the following major sources:

For Operating Expenses—

1. Research and development budget
2. Repair and utilities accounts
3. Maintenance and operation accounts
4. Production and procurement budget
5. Military personnel salaries

For Capital Expenditures—

6. Facilities construction appropriations
7. Housing and base construction appropriations

In addition to the accounting and budgeting of funds in the various ways listed, it appears that the personnel needed for the operating function, both civilian and military, are similarly accounted for and budgeted.

Of the above major sources of funds, the only one over which the Director of Research and Development has substantial cognizance is the research and development budget itself. The Comptroller has stated that, at the present time, it is impossible to identify all of the other costs in categories 2 through 7 which are applicable to research and development. A similar situation with regard to personnel appears to exist. It is difficult to estimate the magnitude of these other costs. At isolated research and development installations such as Holloman and Muroc, the moneys available for operating those bases (not considering capital expenditures) out of the research and development budget constitute approximately 1/20 of the total cost of operating the bases. Of course, this fraction would be much greater at Wright-Patterson Air Force Base.

As a result of the above, it is impossible to know what the actual cost of research and development in the Air Force is, either in terms of money or men. It would further seem impossible to administer adequately a research

and development program when many of the funds and personnel necessary to implement the program are under other than research and development control.

Public Law 216, Eighty-first Congress, amending the National Security Act of 1947 provides in Section 403 (a) for the preparation and presentation of budgets and the accounting of costs on a "performance" basis, so that readily identifiable functional programs and activities can be segregated in terms of their total cost, with a division between operating and capital expenditures. The Hoover Commission Task Force Report on Fiscal, Budgeting and Accounting Activities, which served as one of the bases upon which this portion of Public Law was formulated, emphasized the importance of budgeting and cost accounting by major functions, activities of projects rather than by the things to be used or acquired, such as personal services, contractual services, supplies, material, etc.* Since there can be little question but that research and development is a major function of the Air Force, this new legislation makes possible and points the way toward the consolidation of research and development funds and personnel in an integrated package.

Another approach to the costs and budget of Air Force research and development points to a similar conclusion. From the figures available, it appears that over 70 per cent of the direct costs represented by the so-called research and development budget, item 1, are sub-contracted out to industrial and non-profit organizations. In all such contracts, both direct and indirect costs are included through the mechanism of overhead allowances. Not only do such overhead allowances provide for such costs as administration, repair and utilities, maintenance and operation, etc., but they also provide for amortization of capital investments. We thus find a very substantial portion of what is known as the research and development budget, the part contracted out to the civilian economy, includes indirect costs, whereas that which is performed internally does not. One damaging result of such confusion, in the lower echelons, is the conclusion that it is cheaper and more efficient to do a job internally because the full costs of such internal operation are not apparent.

Budgets should be prepared and accounts be established so that not only the direct costs, but the total costs of the Air Force research and development program can be determined and presented. A similar consolidation of personnel ceilings, both civilian and military, should be effected.

*Page 74, *Task Force Report on Fiscal, Budgeting, and Accounting Activities* prepared for The Commission on Organization of the Executive Branch of the Government, January 1949.

B. PREPARATION OF BUDGETS

Primary responsibility for the initial development of estimates for the so-called research and development budget is presently divided between the Air Materiel Command at Wright-Patterson Field and the Director of Research and Development in Washington. It is not clear to the Committee where or how the responsibility rests for the initial development of budgets for Repair and Utilities, Maintenance and Operation, Military Personnel Salaries, Facilities Construction and Housing and Base Construction, or how the research and development requirements in these areas are taken into consideration. It is clear, however, that a research and development program can not be effective unless integrated plans and adequate funds are available for the supporting as well as the direct activities. This is presently not the case. The only reasonable method of approaching the problem is to give the research and development organization the responsibility for the initial development of all budget estimates where the funds required will be used either for the direct or indirect support of the research and development program.

An important aspect which enters into the problem of the preparation of budget estimates for research and development is the absolute necessity of providing some long-term stability to the various research and development facilities. Competent personnel are essential for the effective functioning of these facilities, but competent personnel cannot be attracted and retained unless the activities at the facility in which they are employed have some long-term stability. Further, the efficiency with which facilities are utilized depends to a substantial extent on a level of work which is not constantly fluctuating. As a result, it seems vitally necessary that the operating organization at each research and development facility have a substantial voice in the development of budget estimates affecting that facility.

Following the initial development of budget estimates, these are reviewed by the Comptroller and then presented to the Air Force Budget Advisory Committee. At the present time, research and development is not directly represented on this Committee. The differences in the nature of research and development from the functions of procurement, distribution and operation, which led to the recommendation of a separate chain of command, also lead to the conclusion that research and development should be directly represented on the Budget Advisory Committee. Further, since the future of the Air Force is largely dependent upon the effectiveness of the research and development program, direct representation on this Committee should benefit the entire Air Force budget picture by the inclusion of a research and development voice in the deliberations.

It appears from the information available that the estimates which finally result in personnel ceilings follow a route comparable to that for research and development funds but are handled separately at a different time. As in the case of monetary budgets, it seems important that the initial responsibility for preparing personnel estimates for both direct and indirect activities should rest within the research and development organization. Further, the handling of personnel ceilings separately from budget funds appears undesirable. The work load, represented to a substantial extent by the funds available, and the numbers of personnel to accomplish the work load, are intimately related; separation of the two will inevitably result in inefficient operation.

Initial research and development budget estimates and personnel ceilings should be prepared by the Air Force research and development organization. They should include all costs and personnel for both direct and indirect activities, and each research and development installation should have a voice in the budget applicable to that installation. Direct representation from the research and development organization should be provided on the Air Force Budget Advisory Committee.

C. "UNIFORM" ACCOUNTING

In addition to the seven varieties of accounts which divide expenditures into direct and indirect activities and which would be brought into the total research and development picture by implementation of the two recommendations above, there are apparently three different accounting systems for use in what is now called the research and development budget. These are (see Figure 1 for 1950 tabulation, page VI-5):

1. The RDB Master Plan Categories and Technical Objectives (18 categories by types of warfare operations, each with definitely allocated funds—appreciable shifts to be approved by RDB).
2. The Air Force Major Program Series—600 (7 programs plus many sub-programs subdivided according to the type of work involved, such as research, components development, systems development, etc., each with definitely allocated funds—appreciable shifts to be approved by the Bureau of the Budget).
3. An AMC Accounting System (by type of expenditure involved, such as research and development contracts, equipment, supplies, etc.).

RDB MASTER PLAN		MAJOR PROGRAM SERIES—600		AMC BREAKDOWN	
1. Airborne Landing Oper.	0.0	610 Research	21.6	R&D Contracts	132.6
2. Air Defense Oper.	18.7	620 Major Weapons		Facilities (Contractors, Plants)	4.1
3. Amphibious Oper.	0.0	Components Development	55.5	Lab Equipment	4.9
4. Anti-submarine Oper.	0.0	640 Weapons Systems		Maintenance of Technical	
5. Atomic Warfare Oper.	2.2	Development	81.4	Facilities	3.6
6. Biological Warfare Oper.	*	650 Operations Eng'n'g	2.5	Supplies	3.5
7. Chemical Warfare Oper.	1.8	660 Human Factors		Personnel	29.0
8. Civil Control Oper.	*	Development	1.5	Travel	1.5
9. Combat Air Support Oper.	15.3	670 Special Project	10.0	Transportation (First	
10. Intelligence Oper.	12.6	680 Management and		Destination)	.8
11. Land Combat Oper.	.7	Operation	42.5	USAF	30.6
12. Personnel Oper.	9.6				
13. Psychological Warfare and					
Cold War Oper.	.4				
14. Sea Combat Oper.	0.0				
15. Strategic Air Oper.	101.1				
16. Submarine Operations	0.0				
17. Supply Oper.	4.4				
18. Supporting R&D	48.1				
Totals	215.0		215.0		210.6**

*Less than $100,000.
**Discrepancy in total budget amount probably due to adjustments in personnel funds.

BREAKDOWN OF RESEARCH AND DEVELOPMENT AIR FORCE BUDGET FOR 1950
(in millions of dollars)
Chapter VI—Fig. 1

RESTRICTED

When the complexities of the above accounting for direct costs are added to those for indirect costs discussed earlier, it appears evident that there is a danger of the accounting system running the research and development program rather than being the tool for effective management which it is intended to be.

Public Law 216, Eighty-first Congress, provides for the establishment of an Office of Comptroller of the Department of Defense, responsible in part for the establishment of uniform systems of accounting for the three Military Departments. "Uniform" systems of accounting is not taken to mean that the procedures used for research and development accounting must be identical with those for procurement and operations, but that the three departments utilize similar accounting systems in their research and development programs. The existence of a Research and Development Board within the Department of Defense, responsible for the preparation of an integrated program of research and development and intimately involved in the budgets for research and development, further signifies an inherent difference between the fiscal operations for research and development and those for other military functions.

The Comptroller of the Air Force and the research and development organization should collaborate closely to develop an accounting system consistent with Air Force research and development requirements. A committee including representatives of the three Services should be established under the Secretary of Defense to work with the new Comptroller of Defense on the broader aspects of accounting systems specifically for the research and development work of all three Departments.

D. OUTLINE OF AN ACCOUNTING AND BUDGET SYSTEM

In the presentations which have been made to the Committee, and in discussions within the Committee, the following diverse objectives have been cited as ends toward which the accounting and budget system should be aimed:

1. The maximum amount of simplicity in preparation of budgets and in accounting for costs, to make management effective and to avoid what presently appear to be overly complicated procedures requiring a large percentage of the time of important research and development personnel from top to bottom.
2. A maximum amount of flexibility, since the very nature of research and development work makes it almost impossible to

predict accurately the costs involved. If the results and the cost of individual research and development programs could be predicted with accuracy, no research or development would be needed.

3. Consolidation of responsibility with authority, so that the individual or organization having a job to do has control over the funds necessary to accomplish that job.

4. A method of emphasizing the types of warfare operations, in terms of the amounts of money allocated to research and development projects which will support such operations. The RDB Master Plan Categories appear to be aimed primarily at this objective.

5. The necessity of providing continuity of support for areas of research and development, particularly in the fields of basic research and components development, where the type of warfare operation or the type of weapon system which will use the results of such work cannot be readily identified. Since almost all new types of warfare operations and of weapon systems will evolve from such basic research and components development, the importance of this support is readily apparent.

6. The importance of providing continuity of support for research and development establishments, both within the Air Force and in contractor's organizations. Competent scientists and engineers cannot be attracted or held, and well-planned programs within such establishments cannot be carried out without such continuity.

7. The necessity of accounting for direct costs, indirect costs, personnel, and facilities, etc., so that management can have some measure of the efficiency of operations and some method for improving efficiency.

It is readily apparent from an examination of the above objectives that the full realization of any one may be incompatible with one or more of the others. The budget and accounting system used must therefore compromise one or more objectives or else combine one or more systems. What seems presently to be in effect is the combination approach, the combination consisting of several parallel budget and accounting systems each aimed more or less at one of the objectives listed. Presumably, each expense is accounted for in two or more separate ways, by RDB Master Plan Category, by the Major Program Series in which it falls, as a contract or some type of internal expense, etc. Such multiple accounting for expenses does not fulfill the objective of simplicity, but may be justified on the basis of the information which it provides for management decisions. However

when expenditures are controlled as well as accounted for in such a fashion, not only are some of the objectives of the different systems realized, but flexibility is destroyed, the complexities of the system become such as to make management almost powerless to do its job. From the viewpoint of the echelons where work is actually performed, almost any budget system, so long as it has a consistent framework, is preferable to several systems which in effect constitute control in several directions at the same time. Therefore, both from the management and worker level, the present method of combining different budget systems seems undesirable and ineffective. A single budget system is the only answer.

For the adoption of a single budget system and its accompanying accounts, some of the objectives listed earlier must be compromised. The budget system discussed in Tab D is suggested as a better method of achieving more of the important objectives than any now in use.

Multiple budget and accounting systems, while intended to provide more information than a single system, are too inflexible and complex to provide a good basis for management decisions. A single improved budget and accounting system is recommended.

E. THE TOTAL SIZE OF THE BUDGET FOR RESEARCH AND DEVELOPMENT

It has been impossible for the Committee to form an adequate opinion on the absolute magnitude which the USAF research and development budget should have. Certain definite conclusions which bear upon this problem have, however, been formulated.

1. The research and development operating budget will increase substantially by the inclusion of indirect costs as well as direct costs and by the inclusion of development presently paid for out of production funds. The data available make it impossible to estimate the amount of the increase. The total Air Force budget should not, however, be affected, except on a long-term basis reflecting greater efficiency in the accomplishment of the research and development program.

2. The research and development operating budget should not be subjected to cut-backs which parallel cut-backs in funds for production and operation; first, because the quality of the Air Force in the future as determined largely by research and development should not be tied to the size of the Air Force as determined by the funds for production and operation; second, because the nature of research and development work makes

necessary continuity and stability of support to achieve significant results; and third, because the type of personnel needed for research and development, whose caliber determines more than anything else the caliber of work done, cannot be attracted and retained without continuity of support.

3. Independent contractors whose existence is essential to the future of the Air Force must have a steady flow of research and development contracts if their technical staffs are to be retained and kept on their toes. There is evidence which indicates that adequate funds are not available for such work, particularly for systems design and engineering studies by the aircraft industry. These studies, in addition to maintaining technical staffs, are important aids for evaluating and guiding trends in components research and developments.

4. The factors which were used as primary guides to determine the size of the Armed Forces' research and development budgets shortly after the war, namely the supply of competent technical personnel to be devoted to military work as compared with the requirements for converting the civilian economy to a peacetime basis, and the availability of large unexpended balances of war-appropriated budgets, have now changed. For the present and the future, the size of the research and development budget should be determined more upon the requirements of strategic concepts and the potentialities of scientific discoveries built up through close cooperation between strategic planner and technical worker, than upon any "magic figure" imposed from above.

5. In general, the rising level of technology will necessitate increasing budgets for research and development and their supporting facilities to keep abreast of the times. In a very real sense, expenditures for research and development represent capital investments in the tools which will fashion the future. An examination of the trends in competitive commercial business shows the strongest recognition of the necessity of increasing budgets for this purpose.

The total budget for research and development must be stabilized to ensure continuity of support to the entire program, including contracts with industry. A steady increase in the relative expenditure for technical purposes should be expected as a result of advances in the technology of air warfare.

VII. RESEARCH AND DEVELOPMENT PERSONNE

A. INTRODUCTION

At the very heart of the problem of improving Air Force research a development and placing it on a firm basis for the future is the urg need for enlightened policies for selecting and managing military a civilian technical personnel of high competence. An organization can effective only when it has competent personnel who are given able, ins ing, and dynamic leadership.

Numerous recommendations have been made to the Air Force on management of scientific and technical personnel.* Many of these rec mendations have been adopted as policy for the conduct of research in Force Regulation 80-4. The Committee appreciates that the Air Fo has been faced with major quantitative personnel problems and research and development personnel constitute roughly only about per cent of the total Air Force strength. It also realizes that there has yet been time to implement AFR 80-4; it is aware of work being d toward this end, including the formation by the Assistant Secretary of Air Force of a Committee on Scientific and Specialized Civilian Perso The present Committee agrees that the personnel problem is one w should and must be of concern at the highest levels in the Air Force, further must be fully appreciated at all levels.

Its observations have convinced the Committee that the technical sonnel situation in the Air Force has been deteriorating over the past years and that immediate and urgent action must be taken to prevent cumulative results of this deterioration from reaching dangerous le The Committee found evidence that many technical officers in rese and development work are trying hard to get out, while those in op tional or other non-technical activities are actively trying to avoid b ordered back into technical work. The major complaints are the follow

1. The lack of sufficient emphasis on technical qualificatio considering reserve officers for integration.

2. The absence of constructive effort to retain in the Air F those officers who received postgraduate training at go ment expense during and shortly after the past war.

*See list of references at the end of this Chapter.

3. The general belief among officers that career advancement cannot be secured by excellence in technical work.

4. Ill-advised rotation and assignment policies which dissipate the skills of the few technically qualified officers possessed by the Air Force.

5. The lack of a career guidance plan for technical officers.

6. Inadequate research and development personnel allotments.

A similarly unsatisfactory situation exists with respect to civilian personnel. The entire research and development establishment is undermanned, recruiting of new personnel of high professional qualifications has in recent years become all but impossible, many of the present civilian personnel are unqualified by educational attainments for the positions they actually hold, and morale among civilian personnel is low. Since the continuity and effectiveness of Air Force research and development depend very largely on the strength and competence of the permanent civilian professional staff, this is an extremely dangerous situation, and one which cannot be allowed to persist. Among its causes are:

1. Firm application of the principle of military management of all activities, without enough technically qualified officers to give competent leadership, and under the handicap of rapid turnover of officer personnel.

2. Lack of stability in programs and aims from year to year; fluctuations in budgetary support for long-term programs; and lack of balance between allocations for expenses, personnel, and facilities for a given project or program.

3. Delays, difficulties, and red tape interfering with the procurement of supplies and equipment needed for the conduct of technical work.

4. The complete inadequacy of housing and community facilities on isolated research and development bases.

5. Substantial differences in privileges and treatment between civilians and officers of the same general attainments and duties, with respect to such matters as club membership, freedom to move about on the base, and so on.

The Air Force is no longer merely a combat arm. It is now a Department with the responsibility of being self-sufficient. It cannot achieve self-sufficiency unless it becomes competent in research and development,

and its research and development personnel situation is the first defect which must be rectified to achieve such competence.

Immediate steps must be taken to husband present Air Force resources of technical manpower, to use presently qualified personnel to maximum effect, and above all to institute policies which will strengthen the technical manpower of the Air Force.

B. INCREASED ALLOTMENTS OF TECHNICAL PERSONNEL

The problem of personnel allotment is relatively easy to handle, since the remedy for the difficulty can be applied by the Air Force itself. The Committee believes that the present research and development personnel allotment is too low. Working largely on new scientific frontiers of the most difficult character, the Air Force is attempting to administer and carry on a research and development program of approximately the same magnitude as that of the navy with only one-third the number of research and development personnel. (See Tab E.) In fact, the Air Force research and development personnel allotments are considerably less than those of the Army, although the Army research and development budget is approximately half that of the Air Force. In terms of professional-grade employees, particularly in the higher grades, the comparison is even more unfavorable to the Air Force.

The net result of these facts is a critical shortage of competent technical personnel to act as staff advisors, to operate laboratories, and to evaluate and administer research and development contracts. Competent p. nnel are overloaded, contractors find themselves dealing with overwork nd inadequately equipped people, and the whole operation suffers. In the of this difficult situation, it appears that, if anything, the present personnel allotment may be cut, this at a time when urgent new responsibilities are increasing the research and development work load.

A stronger appreciation of the importance of research and development in the Air Force would lead to technical personnel allotments more in keeping with realities and essential needs. Any increase in research and development personnel allotments can be made only at the expense of other Air Force activities. The Committee feels that this sacrifice should be made, in view of the urgency of the present situation.

The Air Force should increase allotments of technical personnel for research and development. This can only be done by reducing the force-in-being to

enhance the effectiveness of the Air Force of the future, but in the opinion of the Committee such a sacrifice is necessary and fully justified.

C. LIMITED RESOURCES OF QUALIFIED TECHNICAL OFFICERS DEMAND BETTER UTILIZATION

The Air Force suffers at present from a lack of technically competent officers. Personnel figures given to the Committee indicate that there are about 17,750 regular officers in the Air Force. Only about 1,350 (less than eight per cent) have had any training beyond a bachelor's degree. Of these, only 45 per cent have received a graduate degree, and only about half of this last group have been trained in a technical field. Most of these are relatively young officers who have received their technical training since the war. While some officers without graduate training acquire technical competence through Service experience, a growing number of officers with advanced technical training is essential to Air Force understanding, management, and operation of an effective research and development program.

Most of the reserve officers with technical competence were separated from the Air Force immediately after the war, since they did not wish to dissipate their competence in non-technical overseas assignments. The Committee has heard statements that many of these men would be available for recall to active duty, were it not for their concern lest rotation and assignment policies would soon terminate their ability to contribute to Air Force research and development work.

The total number of technical officers in the Air Force is now far too small to man the present technical jobs, and far too small to permit any rotation of such officers out of technical posts. The over-riding priorities of certain field operations and staff needs should no longer be permitted to take technical officers into fields where their special abilities are little used, and where their experience will not enhance their usefulness to the Air Force. Unsound rotation policies produce situations such as those which the Committee found at certain research and development installations, where the average educational level of the officers stationed at a technical facility was actually below the general Air Force average.

Numerous instances of mal-assignment, or at least of careless and apparently random assignment, of technical officers were brought to the Committee's attention. Instances were cited, for example, of a nuclear physicist who found himself operating an overseas PX, and of other specialists who were arbitrarily ordered overseas into non-technical jobs at times when no competent replacements for them were available. Some of these cases were corrected by drastic personal action. That such cases exist

is an indication that day-to-day operational needs still take precedence over long-range technical needs.

With a critical shortage of technical officers, the Air Force can ill afford to assign such officers—even for limited periods—to jobs which fail to use their talents or broaden their competence. There is no idea here of narrow specialization or completely restricted rotation of officers. A technical officer may properly broaden his experience and competence through assignments in staff work, in intelligence, in teaching at the Air Institute of Technology or the Air University, or even in operational jobs which demand his special abilities. However, to use him as a mess officer, a PX officer, or in similar posts, is worse than a waste of talent. At the end of such an assignment, an officer may well have slipped backward and dulled his technical efficiency through lack of use, or through inability to keep up with advances in his field. The Air Force cannot afford such a loss at this critical period in its growth.

The Committee feels that high-priority action should be taken to improve the utilization of military technical personnel. This improvement is needed too urgently to wait for the preparation and implementation of an adequate career guidance plan for technical officers. The present research and development organizations (and subsequently the recommended Research and Development Command) should have the authority to prevent the assignment to their organizations of officers with inadequate technical qualifications; they should be able to request the assignment of officers with specialized backgrounds, perhaps even by name where necessary; and they should control the limited assignment of technical officers to jobs outside their primary field of competence, for purposes of broadening the experience of the individual.

Until such time as all technical officers are identified and catalogued, these things will have to be done on an individual basis by competent and experienced technical personnel directors. The Committee suggests that this can probably now be done best by the establishment of a Directorate of Technical Personnel in the office of the Deputy Chief of Staff, Personnel, Headquarters USAF. Such a Directorate would coordinate its activities with and handle requests from the research and development organizations.

High-priority action should be taken to improve the utilization of military technical personnel. A Directorate of Technical Personnel in the office of the Deputy Chief of Staff, Personnel, is suggested as a possible interim measure, pending a further study of the problem in connection with the establishment of a Research and Development Command.

D. CAREER POSSIBILITIES AND RECOGNITION FOR ACHIEVEMENT IN TECHNICAL WORK

The professional status of technical officers in the Air Force seems to be doubtful. From limited sampling, it appears that technical officers feel that the outlook for them is not good, that life careers in technical work are not appreciated and are unrewarding, and that command and general officer appointments in research and development work are not attained through technical work. This feeling is especially strong in non-rated officers. The Committee understands that, in recent years, only one officer has attained general officer rank while actually holding research and development assignments.

Presumably, this situation results from the lack of realization throughout the Air Force of the vital importance of research and development. If it is to assume all of the responsibilities of a Department, including that of conducting its own research and development work rather than relying on other Services for it, the Air Force must give a new importance to its technical staff. Its officers must be more competent than those of any other Air Force in the world, and the equal of those of any other Service in the Department of Defense. As a corollary to this, the professional status of technical officers must be among the highest in the Air Force. The whole Air Force must appreciate their unique and indispensable function. This must be made abundantly clear by assuring as rapid promotion in technical work as is customary in any other Air Force activity, by recognition of and decoration for outstanding technical achievement, and by appointing general officers in and for technical work on a basis comparable with that in any other Air Force duty.

For a long time, the effectiveness of the Air Force depended primarily upon the individual performance of its flying personnel. In recognition of this fact, award of the Distinguished Flying Cross was initiated to inspire flyers toward greater accomplishment and to reward them for signal achievement. To an equal extent today, and increasingly in the future, the technical officer as well as the pilot, will determine the effectiveness of the Air Force. The Air Force might appropriately recognize outstanding technical achievement, and encourage high accomplishment of those engaged in technical work, by the authorization of a decoration for distinguished technical achievement.

Such an award should not be made for administrative ability in connection with technical work, but rather for the actual achievement of ideas and discoveries. Several existing awards are intended and used for excellence in a supervisory role. The new award should go to the worker

who has a primary part in an important development. It should be awarded frequently enough to be effective, but not so frequently that it is cheapened.

The increasingly technical character of the Air Force mission calls for a change in the current concept of a general officer as the potential commander of a large operational organization. The impact of science on air power calls for first-rate technical judgment in the formulation of plans and the making of decisions at the highest command levels. The Air Force high command can no longer afford to deny itself this first-rate technical competence by requiring brilliant technical officers to dissipate their special skills in unrelated activities as a prerequisite to qualification for general officer rank. An analysis should be made of general officer jobs which demand primarily specialized competence, and promotion boards should be instructed to select especially competent officers for general officer assignments even though they may not have all of the "well-rounded" operational experience heretofore demanded.

The professional status of technical officers must be among the highest in the Air Force, and this must be made abundantly clear by promotion in technical work as rapidly as in other activities, by opportunity for promotion to general officer rank in and for technical work, and by recognition and decoration for excellence in such work. The Committee recommends that the Air Force consider establishing a decoration ranking with the Distinguished Flying Cross to reward outstanding individual achievement in research and development.

E. MEASURES TO INCREASE TECHNICAL OFFICER STRENGTH

The Air Force should make at once an effective personnel inventory to identify and catalogue technical officers. This inventory should not be on too narrow a basis of specialization, but rather should recognize broad fields of scientific and engineering training and competence.

The Air Force should institute as soon as possible a career guidance plan for technical officers. The plan should be drawn up with the help of the best professional advice, and should provide that technical officers be given assignments which use their special skills, as well as insuring that such officers have a properly controlled rotation to broaden their experience and to acquaint them with an adequate range of Air Force activities and operations. The plan should also secure for technical officers an

equality of opportunity with other officers, both for assignments and for promotion.

The Air Force postgraduate training program should be continued on an increasing scale. It is presently inadequate in comparison with the long-established postgraduate program of the Navy, whose mission is certainly no more specialized or technical than that of the Air Force. This training program must be integrated with the inventory and career policies suggested above, and supported from the very highest levels (e.g., the Chief of Staff and the Secretary of the Air Force) in such a way as to attract and enroll the very ablest of the officers having an aptitude for this training.

In view of the time required to repair the shortage of technical officers through training of officers presently commissioned, it is suggested that immediate steps be taken to augment the supply of specialists by some or all of the following procedures, which are arranged in order of priority:

1. Assignment to technical posts of properly qualified Air Force officers now on non-technical duty.

2. Transfer of officers with technical competence and ability from the other Services. The Navy is especially rich in competent commissioned personnel.

3. Recall to active duty and transfer to regular status of technically trained reserve officers. To be effective, this step will require the sacrifice of some reserve officers with non-critical military occupational specialties; controlled technical assignments for the officers recalled to active duty; and enabling legislation to permit the integration of additional officers, together with plans which ensure adequate emphasis on technical qualifications during this integration.

4. If necessary, the commissioning from civil life of engineers and scientists of high competence and proper qualifications for Air Force research and development work.

5. As an immediate expedient, the assignment of highly qualified civilians as heads or deputy heads of units normally commanded by officers, in order to ensure the needed technical competence in such posts.

The Air Force should make an inventory of technical officers, institute a career guidance plan for such officers, step up the scale of the postgraduate training program, and take immediate steps to augment the supply of officers with advanced technical training.

F. MANAGEMENT OF AND PROFESSIONAL OPPORTUNITIES FOR CIVILIAN TECHNICAL PERSONNEL

Air Force research and development installations are essentially military operations which will and should continue to function with combined military and Civil Service personnel. Military authority is required at the top of such an organization. However, in the subordinate management posts, military and civilian personnel can be used interchangeably. Professional technical competence is a more important criterion for a leader than is classification as an officer or as a civilian. A measure of civilian control is important to give continuity and consistency to the work of the installation, and to encourage civilian personnel to strive to fit themselves for posts in management. Military control is important to ensure that the viewpoint of the experienced user of equipment is given weight in design and development decisions.

In general, the Committee feels that the civilian voice in management of research and development work might well be a function of the degree of remoteness of the work from an end item of military equipment. Thus, basic research might be entirely controlled by civilians, while experimental aircraft projects should be managed by technically qualified officers. However, under no circumstances should an officer control technical work, at any level, unless he is fully competent technically and can command the respect and cooperation of his qualified technical personnel. There can be no greater source of weakness in research and development operations than that which arises from the arbitrary placing of all authority in military hands, regardless of competence. Equally unsatisfactory is a joint authority in which an officer and a civilian sit together in an office and undertake jointly to do a job, under conditions in which the authority resides in the officer and the civilian has the responsibility. The rapid turnover of technical officers makes this problem particularly acute. The Committee is aware that the Air Materiel Command has put civilians, in a very few instances, into such posts as that of laboratory chief in the Engineering Division, but this practice should be very greatly extended and made use of at higher levels as well.

In addition to the frustrations which competent civilian personnel inevitably feel when they are managed by incompetent officers who are in positions of authority simply because they are officers, there are other —and perhaps more important—frustrations which arise from the instability of the Air Force research and development program. Aims and major programs change from year to year, support in terms of funds and personnel fluctuates in accordance with decisions in which the technical staff has little or no part, and delays and difficulties beset the procurement of supplies and equipment needed to do the job. Further, there is often an important lack of balance between allocations of funds, personnel, and

facilities for a given program. Under such circumstances, it is difficult for even the most devoted technical employee to feel that he is making a real contribution to the Air Force of the future.

Progress has already been made in the direction of enhancing the professional privileges of civilian technical personnel. Two examples are the Ohio State University graduate extension courses offered at Wright Field, and the increasingly liberal policies in regard to attendance of civilian personnel at professional and scientific meetings. The Committee feels that efforts in this general direction, in consonance with the policies set forth in AFR 80-4, should be continued and extended to cover such matters as full-time assignment to civilian institutions for graduate study, exchange assignment with other government research organizations such as the National Advisory Committee for Aeronautics, and limited assignment to Service schools and operational activities. The Committee firmly believes, however, that all these matters are supplementary to a stable technical program in which the civilian technical employee can feel that he is taking a substantial and useful part.

The key to attracting and retaining highly competent civilian technical personnel lies in providing openings for important management jobs, stability and significance in Air Force research and development programs, and additional emphasis on opportunities for professional improvement.

G. RECRUITING OF COMPETENT CIVILIAN PERSONNEL

Improvement of working conditions for professional civilian employees will, of course, be the most important step that the Air Force can take to better the situation with regard to recruiting of technical personnel. In peacetime, competent civilians will be attracted to government service only by employment practices which yield working conditions, including intellectual freedom, personal dignity and rewards, and cultural opportunities that are not inferior to those freely available in the research laboratories of industry and the universities.

The evidence that technical work for the Air Force does not now provide such rewards is overwhelming. The Committee was told that about 30 per cent of the professional civilians in the Air Materiel Command are not educationally qualified for the grades they now hold; the rate of turnover of civilian professional employees in Air Force installations is appreciably higher than that in the Navy and Atomic Energy Commission activities visited by the Committee; and it has proved almost impossible for the Air Force to recruit qualified civilians for P-8 and P-9 vacancies in the Air Materiel Command.

Improvement of the educational qualifications of civilian personn can be achieved by proper recruiting policies and by sound manageme with regard to promotion and assignment. In the future, care must be take that no promotion to a higher grade is made on the basis of seniority, o to fill a vacancy, without attention to the educational attainment level re quired for the new post.

Recruiting for the higher professional grades will continue to b difficult, and the personnel turnover will remain relatively high, unti major steps have been taken to implement AFR 80-4 and thereby to estab lish working conditions which are competitive with those available in industrial or university research work.

A major problem at remote bases is the lack of adequate housing and community facilities for civilian technical personnel. The Committee recommends as a cardinal peacetime principle that living conditions at isolated bases be made to approximate as closely as possible those available in conventional communities. The Air Force is presently trying to operate several facilities having only makeshift accommodations left over from deteriorating wartime temporary bases. It will be difficult to correct this condition, but the problem must be faced and measures for its solution must be given an over-riding priority.

Many of the problems of civilian personnel management were recognized and discussed in the presentation made to the Committee on behalf of the Deputy Chief of Staff, Personnel. Some needs for legislative changes were pointed out. However, much can be done within the existing legal framework by enlightened administrative action and improved official attitude.

The Air Force has already made much progress in civilian personnel administration. In most of the bases visited by the Committee, the commanding officers expressed keen interest in and concern with the problems of civilian employees. The Committee, however, could not fail to notice the contrast at the Navy stations visited, where the civilian specialists played a major role in the briefings and obviously carried a large part of the responsibility for the work of the stations.

Successful implementation of Air Force Regulation 80-4 will improve the morale of professional employees and will in large measure solve the problems of recruiting technically qualified civilians. There is presently an urgent need for improved practices which can be instituted under the existing legal framework.

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VIII. FACILITIES FOR RESEARCH AND DEVELOPMENT

A. INTRODUCTION

Research and development aimed at the creation of new methods and implements of warfare depend on physical facilities that are unique, complex and expensive. Much time is required to design and construct such facilities, and the rapid pace of modern science calls for the highest type of planning to ensure that facilities are ready when needed.

Air Force research and development facilities were in general well planned and integrated prior to World War II. However, the tremendous expansion of the Air Force necessitated the establishment of new field facilities without the opportunity for systematic planning. Major post-war problems have conspired to prolong the existence of a haphazard pattern of field facilities which are supported to an ever varying extent from year to year and housed principally in antiquated buildings of temporary wartime construction.

In the short span of its independent existence, the Air Force has had no opportunity to formulate an integrated long-range facilities plan. While efforts at unified planning of facilities are not lacking, such efforts have been crippled by delays in implementation due to legislative problems and inadequate budgetary support.

The Air Force is well aware, at the top levels, that a well thought-out system of facilities must be implemented if a strong and healthy research and development program is to be maintained. An excellent first step in the direction of such far-seeing planning has already been taken in the Air Engineering Development Center and the Joint Long Range Proving Ground, in which the Air Force collaborated with the other Services in creating nationwide plans, properly coordinated by the Research and Development Board.

The present haphazard pattern of Air Force research and development installations must be organized into a carefully planned and implemented system of modern facilities.

B. LONG RANGE PLANNING OF FACILITIES

To provide new facilities for which there have been urgent and immediate needs, the Air Force has generally requested funds for individual

construction projects or "packages" that could be readily justified in themselves. To replace this piecemeal process by the formulation of a consolidated plan that can be realized step by step as funds are granted is a matter of technical necessity, if a sound physical basis is to be provided for future activities. But more important than that, such planning is, in the view of the Committee, a most urgent political necessity, if the Air Force is to maintain its leadership as the principal exponent of the essential techniques of modern and future warfare.

A long range plan for research and development facilities must not be thought of as an inflexible and rigid pattern that must be adhered to at all costs for a number of years. On the contrary, it must be capable of continuous adjustment and modification in accordance with the organic growth of the entire research and development program.

The existence and implementation of such a plan will successfully avert a number of quite serious and imminent dangers:

1. The time required for the development of new weapons is itself one of the critical factors in technological warfare. Major delays in reaching production are potentially as disastrous as technical inferiority in design. Such delays will inevitably occur when the need for physical facilities for development or test has not been properly foreseen or, if foreseen, the facilities have not been provided. The lack of wind tunnel facilities which were proposed for AEDC several years ago is already beginning to affect the development of jet engines in this country.

2. The expansion of facilities by adding individual units in response to the needs of the moment may lead to a facilities structure that cannot be financially maintained. Each new facility imposes a growing burden of fixed charges on future research and development budgets and manpower, leaving in proportion a steadily shrinking balance for developments in new directions. Facilities for modern weapons development are becoming so elaborate that the utmost efficiency must be achieved, not merely for reasons of old-fashioned governmental economy, but in realistic recognition of the limits of our national income and manpower resources.

3. Congress is showing an increasing concern for the full utilization of research and development facilities. The joint use of such facilities by the Army, Navy, and Air Force, together with other government agencies, will be and should be fully explored. By taking the initiative in this exploration, the Air Force will

avoid the severe disadvantages that may otherwise result from joint operation under provisions that are imposed rather than planned.

4. The technical manpower of the nation, especially in the top grades, is limited. Careful studies have indicated that this condition will continue for many years. Only by aggressive leadership in planning modern facilities will the Air Force be able to attract the top talent that it should have, commensurate with its outstanding responsibilities in providing for the nation's security. The Committee, in its recent survey of Air Force and other establishments for research and development, has been strongly impressed with the danger that the best available scientific talent may in time be gathered by other laboratories, notably those of the Navy and the Atomic Energy Commission, and that only the culls may be left for the Air Force.

To maintain the leadership of the Air Force in providing for national security, it is essential that the Air Force take the initiative in presenting to the nation a plan for research and development facilities that is realistic in budget requirements, constructive in inter-Service collaboration, and attractive to top grade technical personnel.

C. TECHNICAL REQUIREMENTS FOR FACILITIES

The basis for all planning of facilities must be the research and development program of the Air Force. As new knowledge accumulates, it affords glimpses of the probable direction in which future investigations will move, and permits a forecast of the requirements for physical facilities. This advance knowledge will reside principally in the scientists and engineers of the proposed Research and Development Command, and it must become one of their most important duties to formulate plans for a system of facilities that will provide complete coverage of the research and development program. The formal authority for this function will probably be assigned to a facilities office which will carry out its planning activities in close concert with the Research and Development Board, and with assistance from the Scientific Advisory Board.

It will often be possible to meet new requirements with only minor modifications of existing facilities. The chances of thus extending the exploitation of facilities grow as more thought is spent on providing flexibility in their design. This objective must not be pursued to the point of making the facility so versatile that it no longer performs really well in any particular application. However, between this extreme and a com-

pletely rigid facility that meets one and only one requirement, there exists a proper solution which sound technical judgment will indicate.

The shortages of money and personnel in relation to the manifold needs for research and development make it mandatory to conduct a thorough survey of all existing facilities whenever a new technical requirement arises. Installations controlled by universities and by industry should be considered along with all government and service laboratories and test stations. No facility is ever completely duplicated by another, but the Committee has noted several instances in which facilities were not fully utilized, and where useful consolidation of effort might be accomplished without much modification. This possibility might be explored with particular profit in the guided missile test program where work involving short and intermediate distances appear to be simultaneously in progress at Holloman, White Sands, Inyokern, and Point Mugu.

An essential feature of a sound plan for facilities is the timing of the various elements in accordance with the anticipated development schedule. The facilities needed in the early stages of a new weapon may be quite different from those required for the final tests, and the availability of equipment for the final tests cannot compensate for the lack of intermediate facilities. For example, from the point of view of the over-all program, the Air Engineering Development Center, suitable short- and intermediate-range guided missile test facilities and the Long Range Proving Ground should be implemented in that order. The strong and active support recently shown for the Joint Long Range Proving Ground must be supplemented by intensive effort on the first two facilities if a balanced situation is to be achieved.

The Research and Development Command should be responsible for planning facilities in terms of the anticipated technical requirements of the research and development program, with due regard for flexibility of design, for maximum utilization of existing facilities, and for proper scheduling of new construction.

D. REMOTE AND ISOLATED FACILITIES

The nature of certain important tasks in Air Force research and development calls for laboratory and test facilities in relatively uninhabited regions. Numerous factors conspire to drive such work away from civilization; the hazards of fire, shock, and contamination; the nuisance of noise; the need for large amounts of energy and space, or for special atmospheric conditions; and finally the requirements of security. These remote facilities must be used for complex purposes by highly specialized

scientific personnel who are almost invariably accustomed to the conditions of life in large urban centers. This gives rise to complications so serious that operation at remote stations should be considered only under the pressure of the most compelling reasons.

The Committee has given careful attention to the important problems peculiar to remote stations, and has considered the many possibilities ranging from large and self-contained communities such as Inyokern to purely technical facilities with a minimum number of resident caretakers such as Mt. Palomar. No single conclusion of universal applicability can be drawn, but by and large the Committee believes the Air Force should avoid the pattern established by the Navy at Inyokern, where the physical apparatus for a modern community of over 10,000 souls has been set up in a previously uninhabited desert region.

Instead, the Committee recommends that the number of permanent residents at remote facilities be kept down to the minimum consistent with proper maintenance and use of the essential technical equipment. Scientific personnel involved in the conduct of a specific test should be moved to the remote facility as a separate task force for the duration of the assigned test. The more extensive job of preparing the test, building special instrumentation, reducing the data, and preparing the report should be done at a base headquarters laboratory located in an urban community. Here also would be all supporting technical facilities for those phases of the development program that can be safely and satisfactorily carried out in town, and here the scientists and engineers would live with their families. In the Committee's opinion, this principle of operation will be more economical, in spite of the augmented expense for personal transportation, than the creation of complete community services at a remote station. Moreover, it will enable the Air Force to secure for such stations the services of many scientists and engineers who are reluctant to remove their families from life in a normal civilian community.

This recommendation should on no account be misconstrued as condoning the appallingly inadequate base and housing facilities at a place such as Muroc Air Force Base, which should form a permanent part of the research and development plant. These should, in fact, be promptly improved to provide acceptable living conditions for the people who must be on permanent and transient duty at these stations.

> **Where facilities must be established in remote and isolated regions, they should be limited to the minimum equipment and personnel consistent with safe and effective operation. Where possible, all supporting activities should be located at a base**

facility in an urban center, and technical work at the remote station should be performed by task forces moved there for short periods.

E. CONTRACT OPERATION OF FACILITIES

The operation of research and development facilities by outside contractors has been practiced with considerable success by the Atomic Energy Commission. The Los Alamos Scientific Laboratory, for example, is operated by the University of California, and the extensive community services at that station are handled by the Zia Corporation. Negotiations are now in progress for the operation of the Commission's Sandia Laboratory by the Western Electric Company and the Bell Telephone Laboratories.

The Committee believes that this type of operation constitutes a particularly satisfactory mechanism for bringing competent civilian effort to bear upon the research and development program of the Air Force. The personnel assigned to the job by the contractor are often backed up by the extensive experience of the contractor's entire additional staff. The contractor is free to establish personnel policies that will secure optimum results in the situation at hand, independent of the restrictions of Civil Service regulations. The Air Force, in turn, can concentrate its limited resources of technically trained manpower on those problems like contract supervision and operational evaluation that must necessarily be carried out by Air Force personnel.

Complications may arise in such arrangements when the contractor is in commercial competition with others who could effectively use the facilities. On occasion, the Air Force has provided facilities for manufacturers engaged in development work under Air Force contracts. The usefulness of such facilities would often be widened by having a disinterested group, such as a university, operate them for the benefit of the entire industry. The association of a facility with a specific contract may also result in sudden and wasteful termination at a time when that contract is cancelled. This appears to have happened, for example, in the case of the supersonic aerodynamics facility at the Packard Motor Car Company in Toledo, Ohio. Generally a healthier situation will prevail if especially elaborate facilities are established by the Air Force as part of its own over-all program, and operated at locations convenient to present and future contractors.

Contract operation of government facilities has been successful in providing competent civilian staffs for research and development work, and should be adopted by the Air Force as circumstances permit. Elaborate facilities provided for

manufacturers engaged in development work should be operated by a non-competitive organization, and be accessible to all contractors.

F. INTERIM ACTIONS WITH RESPECT TO FACILITIES

Considerable time will be required for the study and planning which must precede the evolution and implementation of a long-range facilities plan. In the meanwhile, interim action is urgently needed to give necessary support to existing Air Force facilities, and to give primary implementation to some of the plans which call for vitally needed new facilities.

The following comments are made on the basis of a rather brief study of the over-all facilities problem by the Committee. They are intended to illustrate the application to specific problems of the principles enunciated above, as well as to propose specific actions with respect to Air Force research and development facilities.

MUROC AIR FORCE BASE

The dry lake at Muroc Air Force Base provides experimental flight test facilities which are unique and indispensable to the program of experimental aircraft development. The Committee feels strongly that Muroc should be implemented on a permanent basis. This will require limited but permanent technical facilities, including hangars and instrumentation buildings for flight tests of experimental aircraft. It will also require adequate housing and community facilities for the minimum staff which must be permanently located on the base, together with adequate accommodations for transients.

The program of land acquisition should be given high priority in order to protect the unique advantages of this facility from the inroads of farmers and others who are moving into the immediate area of the base. The activities of the mud-mining companies who are cutting the lake in two should be halted at once, and the present damage to the lake repaired. Finally, the railroad which now crosses the lake should be rerouted, thus removing the only remaining landing obstruction.

Muroc Air Force Base is a unique facility of great importance to the Air Force. It should be properly implemented on a permanent basis as a top-priority project.

THE ARMAMENT CENTER

It is apparent to the Committee that the development of bombing and fire-control systems is presently lagging behind aircraft development. Further, the Air Force lacks adequate facilities for the flight testing associ-

ated with air ordnance development and engineering test. These two circumstances have given rise to the present situation, in which a considerable amount of air ordnance development work is actually accomplished at the Air Proving Ground, Eglin AFB, during operational suitability tests of new aircraft.

In what follows, the term "air ordnance" refers to guns, bombs, artillery rockets, and other items generally regarded as ordnance, together with the necessary fire-control and bombsight systems. The Committee wishes to avoid the use of the term "armament," since its current definition in the Air Force includes guided missiles, to which the following discussion is not intended to apply.

The Committee strongly supports the need for flight test facilities in connection with air ordnance development and engineering tests. However, it wishes to question the choice of Eglin Air Force Base as a suitable location for the Armament Center.

It should be noted that, to an ever-increasing extent, the radical flight characteristics of experimental aircraft are forcing the concentration of experimental flight test work at Muroc AFB. Armament flight development work will therefore automatically suffer a setback if it has to be delayed until routine flights can be safely made from normal airfields such as Eglin AFB. Furthermore, during the experimental flight development of a new aircraft, every design change which is found necessary must be balanced against many other requirements. It is true that the project engineers of the manufacturer and the Air Force generally work together in making important engineering-change decisions. This can be done far more efficiently and far more effectively if all development work is concentrated at one location.

The Committee is also concerned lest the integrity and detachment of the operational suitability testing which is proper business of the Air Proving Ground suffer or be compromised by the conduct of development and technical suitability tests on the same base, and with the use of some of the same facilities.

An Armament Center is urgently needed by the Air Force. However, the desirability of locating this Center at Muroc AFB rather than at Eglin AFB should be more carefully evaluated, before proceeding with its implementation.

THE AIR ENGINEERING DEVELOPMENT CENTER

By the end of 1944, jet propulsion had shown the way to flight at supersonic speeds. The advent of this new technical era led to a major

effort to provide the new facilities required as tools for developing supersonic aircraft and missiles. The planning phase of the Air Force effort culminated in the summer of 1945 in a proposed Air Engineering Development Center, with facilities capable of making an integrated attack upon the problems associated with supersonic flight. Its facilities include several large wind tunnels for research, development, and evaluation in the supersonic and hypersonic speed ranges and altitude flow chambers for testing jet engines at simulated high altitude conditions. The magnitude of the project necessitated separate enabling and appropriation legislation for the AEDC.

In view of the importance of supersonic research facilities to the nation as a whole, the NACA formed a panel composed of representatives of all interested agencies. This panel produced the Unitary Wind Tunnel Plan. On this basis, after full inter-Service coordination, the AEDC facilities were approved by the RDB in May 1948.

Enabling legislation has been introduced before the 81st Congress. Strong top-level support has greatly accelerated the process of securing the passage of this enabling legislation. Continuation of this support should insure the final overcoming of legislative and budgetary problems, thus finally making possible the urgently needed implementation of the Air Engineering Development Center.

The long time required to launch the AEDC has already resulted in costly but unavoidable interim measures. For example, a guided-missile range had to be established at Holloman AFB, and the Torrance or other suitable ram jet test facilities must be currently implemented to meet the urgent ram jet testing needs of the research and development program.

The high power and water requirements of the AEDC greatly complicate the site problem. The philosophy outlined above in this chapter is being pursued in choosing a site which best meets the complex technical, economic, and personnel requirements. Such factors as: extension of the periods of high power operation to a possible maximum, low initial cost, low operating cost, attractiveness to scientific personnel, proximity to aeronautical industries and universities, and suitability for military testing have to be considered in arriving at a solution to the site problem.

It may not prove possible to locate the AEDC wind tunnels on the outskirts of an urban area which offers suitable housing, community services, and intellectual and aeronautical industry contacts for the staff, all without direct cost to the Air Force. In such a case, the tunnels alone could be located where the requirements for water and power can be satisfied. The permanent staff at the tunnels would then be limited to the maintenance personnel and a skeleton operating crew; tests would be run by transient crews, who would remain in the isolated station only for the actual period required to complete their work in the wind tunnels. This scheme

of operation is familiar in the field of astronomical observation. Good "seeing" can only be found in remote places, where great telescopes must therefore be located. The observatory staff, however, is customarily housed at the home institution, each member traveling to the telescope only on those occasions when he has been assigned the use of the instrument in connection with his work.

Provided that the AEDC wind tunnels are to be located in an area which affords sufficient security and safety, simultaneously with their design, the air blast requirements for testing future nuclear propulsion systems should be estimated, bearing in mind the possibility of conducting tests on such systems at the AEDC tunnel site. The initial development of nuclear reactors intended for aircraft propulsion will be extremely hazardous, and will undoubtedly be carried out by the Atomic Energy Commission in special facilities designed with such hazard in mind. However, it seems reasonable to presume that nuclear reactors may eventually become safe enough to be considered for Service use, in which event the development testing of engines using nuclear reactors in place of combustion chambers might be usefully carried on at the AEDC. Consideration of this possibility at the present time might obviate the need for additional expensive facilities at a later date.

Strong top-level support has greatly accelerated the process of securing the necessary enabling legislation for the Air Engineering Development Center. Continuation of this support should insure the final overcoming of legislative and budgetary problems, thus finally making possible the urgently needed implementation of the AEDC.

THE TORRANCE RAMJET TEST FACILITY

The pressing requirement for ramjet test facilities in connection with the guided missiles program was not filled at the appropriate time because of the long coordination procedure which has delayed implementation of the AEDC. The immediate and urgent need for a large air supply for testing ramjet engines can be filled by the modification of existing equipment located at a wartime butadiene plant in Torrance, California. The availability of so much of the needed equipment in convenient proximity to important ramjet contractors was indeed extremely fortunate.

The Torrance Ramjet Test Facility or another suitable ramjet test facility should be promptly implemented to meet specific needs of the Air Force guided missiles program.

HOLLOMAN AIR FORCE BASE

The large desolate areas in south-central New Mexico are well suited for flight testing of short-range and intermediate-range guided missiles. The Air Force urgently needs permanent missile-test facilities. However, the question of permanent implementation for Holloman AFB cannot be easily resolved, primarily because of the variety of uncoordinated facilities which have so far resulted from inter-Service competition in the guided missile field.

The Committee feels that the following two alternatives should be given careful study as economical and effective guided missile test facilities:

1. Combination of the Army Ordnance White Sands facility with Holloman AFB, followed by joint operation of this combined facility as a test station for short- and intermediate-range missiles.

2. Joint Air Force-Navy operation of the Naval Ordnance Test Station at Inyokern (short-range missiles) and the Naval Air Missile Test Center (intermediate-range missiles) at Point Mugu.

The Committee believes that the Air Force can greatly strengthen its position in the guided missile field and enhance even more its own stature in the eyes of the Research and Development Board and of the Congress by taking the initiative in this matter. A strong stand should be taken in favor of one of these suggested alternatives, or on some similarly economical joint plan, as determined by a special study of this problem which should be made.

Based on the results of a comprehensive study, the Air Force should move with all speed to implement on a permanent basis the joint operation either of the Holloman-White Sands complex or the Inyokern-Point Mugu combination, in order to provide an adequate facility for testing guided missiles of short and intermediate range. The study should also determine the additional facilities for experimental test which may be eventually required.

IX. OPERATING PROCEDURES FOR RESEARCH AND DEVELOPMENT

A. INTRODUCTION

It is one of the characteristic features of research and development work that its performance does not lend itself to standardization of procedure. Generalization on matters of procedure are therefore hazardous, and the methods by which successful performance is achieved vary with the individual situation. To attain the important objectives of internal efficiency and of satisfactory collaboration with industry and other outside agencies, the Air Force must depend principally on the experience and judgment of the scientists and engineers who occupy responsible positions in the program. The Committee has therefore limited its comments on procedure to a few special problems encountered in the course of its survey.

B. SYSTEMS ENGINEERING IN THE AIR FORCE

During World War II, for the first time the distinction between **components** and **systems** was recognized more clearly. The distinction is not a hard-and-fast one that can be uniquely drawn, but it is nevertheless useful. A **system** is an assemblage of interacting parts, or **components,** brought together to deal with a particular problem. Thus the Air Force as a whole can be thought of as a system comprised of aircraft, men, motor vehicles, fuel and ordnance, and altogether designed to wage air war. However, it is ordinarily more useful to consider systems at a lower level—to conceive of the Air Force as an assembly of systems, designed to accomplish the various missions of strategic bombardment, air defense, tactical air operations, air supply, and so on.

Within each system so defined, sub-systems can be usefully distinguished. Thus the system for strategic bombardment contains a sub-system concerned with fighter escort, for example. The systems and sub-systems are made up of components which, at our level of consideration, are individual aircraft types, bombs, ground radar sets, etc.

Technical advances in all fields are made through a combination of improved components and improved techniques for linking these components into systems. Sometimes these improvements originate with the engineers primarily concerned with the design of components; sometimes they come about because the concept of a system shows that a particular part of the desired system is missing. It is most fruitful for ideas to flow both ways between the components engineers and the systems engineers.

The present organization of the Engineering Division of the Air Materiel Command places a substantial emphasis on the components of aircraft systems. This seems sound from the standpoint of fostering advancement in the specialized items and techniques of which new systems will be composed. The Committee believes, however, that present over-emphasis on the importance of the components laboratories has given these laboratories too much control over the systems themselves, rather than keeping the components laboratories to their proper role: that of fostering the development of new components and new component techniques.

Probably the most important consideration which has led to the present commanding position of the components laboratories in the Engineering Division is that this policy will lead to greater standardization and fewer different components of the same sort (engines, instruments, propellers, etc.), and therefore will increase economy and simplify logistic problems. The Committee is not unmindful of the great desirability of economy and simplified logistics. Where over-all performance is involved, however, the Committee feels that these considerations should not govern system design.

Aircraft project officers are, in a sense, systems engineers, though it may often be worth while to consider systems larger than a single airplane. This is especially true in air defense, where the design of an interceptor aircraft depends so completely on the nature and the capabilities of the ground-based search and warning equipment. The Committee feels that the autonomy of the project engineer might well be increased, that project engineers for larger systems might be maintained, and that systems problems should be constantly considered by mixed teams of components and systems engineers brought together to consider the various large operating problems of the Air Force.

Within the Air Force, the role of systems engineering should be substantially strengthened, and systems projects should be attacked on a "task-force" basis by teams of systems and components specialists organized on a semi-permanent basis.

C. CONTRACTS FOR SYSTEMS AND SUB-SYSTEMS DESIGN

Except for guided missiles contracts, it is presently customary for the Air Force to contract with industry for only one component of a more or less complicated system. In the case of an airplane, for example, logistic requirements may dictate that the engine and many of the accessories be specified by the Air Force to the airframe manufacturer. In addition, the

system concept calling for a particular aircraft type has heretofore been taken by the manufacturer as given by the Air Force.

This practice implies, of course, that the Air Force itself is the best source of judgment, planning, and system design. Sometimes, and in connection with some systems, this is no doubt perfectly true. Certainly the various military factors which surround the practical problem of operating a system are best understood by Air Force officers with actual field experience. To an increasing extent, however, systems planning is becoming a very complex and highly technical task. This is already obvious, for example, in the air defense problem.

There is a very important reservoir of talent available for systems planning in the engineering design staffs of the industries of the country. Many single contractors, by calling on their own staffs and by subcontracting with others, can enlist the aid of a greater number of competent technical people than the Air Force itself could muster to attack a problem of systems design.

The Committee believes that a valuable freshness of approach to systems problems could be secured if the Air Force made a practice of obtaining the services of industrial contractors for systems design problems, from comprehensive sub-systems involving a number of related components to the major weapons systems such as air defense, tactical air operations, strategic bombardment, etc.

Doing this would not imply that the Air Force is vacating its primary responsibility for determining the detailed way in which it is to carry out its mission, for the final burden of deciding upon a preferred system must always rest with the Air Force; however, much outside help can be secured prior to making that decision.

To enlist the effective aid of industry, it is not essential that the problems to be solved fall naturally or completely into the normal activities of a particular company, nor that profit through eventual production contracts be a primary incentive. It is the belief of the Committee that where comprehensive and challenging problems can be identified and are vital to the Air Force, contractors can be found who will accept the challenge and see to it that the best thought and skills in the country are applied to the solution of such problems.

The Air Force should enlist more general and more effective industry cooperation by contracting not merely for components, but also for the solution of system and sub-system problems.

D. CONTRACTUAL ARRANGEMENTS FOR RESEARCH AND DEVELOPMENT

At present, about 70 per cent of the direct expenditure for Air Force research and development represents payments on contracts with industries and universities. Elsewhere in this report it is recommended that such contracting be increased both in scope and in magnitude, and that consideration be given to the operation under contract of certain research and development facilities. In order to be fully effective, however, the contractual arrangements used must differ substantially from those used in the procurement of production quantities. The results of research and development projects cannot be accurately predicted in terms which are normally used when ordering things of which complete designs already exist.

In research and development, the "product" that is purchased is services: the services of organizations and of individuals who will apply their knowledge and abilities to the problems presented to them. The most important decision to be made in letting a research and development contract is thus the selection of the most competent organization to attack the problem at hand. Once this decision has been reached, the widest latitude needs to be given to the contractor to attack the problem in the fashion he thinks best. Performance often cannot be judged on the basis of the delivery of concrete things, but rather on an evaluation of the wisdom with which the contractor has attacked the problem.

Recognition by the Army of the factors mentioned above led some time ago to the appointment of a broadly representative committee to make recommendations to the Army on improved procedures for the negotiation and administration of research and development contracts. The report of this committee, entitled "Report of the Advisory Committee on Contractual and Administrative Procedures for Research and Development for the Department of the Army," was submitted on 15 October 1948. Many of the recommendations contained in that report can be usefully applied to similar problems in the Air Force.

At the present time, substantially all contracts for research and development are prepared and administered from a contractual standpoint under the Directorate of Procurement and Industrial Planning in the Air Materiel Command. Except for a separate branch of the Procurement Division handling research contracts primarily with universities, research and development contracts are processed by the same branches that handle production contracts for the same type of item. As a result, the principles and practices used are primarily adapted to supply. The contracting officer, who is the channel of authority between the Air Force and the contractor, is not subject to the authority of those charged with the responsibility for

research and development, thus authority and responsibility are separated. In contracting for research and development work, continuous contact and interchange of ideas between the Air Force research and development organization and the contractor is essential, so that the channel of authority and responsibility should be direct.

The Committee is aware that the job of contracting by the Air Force is a complicated one affected by the fact that the Air Force, as a government organization, must comply with a variety of laws and regulations. The size and importance of the research and development operation is great enough, however, to justify a separate contracting organization. Efficiency would actually be served by decentralizing the contracting function to the extent of creating a separate contracting group for research and development contracts. This group should be a part of the organization which is charged with the responsibility for conducting research and development for the Air Force.

The Air Force organization responsible for research and development should have its own contracting group, separate from the group responsible for supply contracts, in recognition of the fact that procedures and regulations best adapted to handling research and development contracts differ importantly from those appropriate to production contracts.

E. PURCHASING AND SUPPLY FOR RESEARCH AND DEVELOPMENT

During the course of its study the Committee has repeatedly encountered situations in which research, development, and test work performed at Air Force installations is greatly hampered by cumbersome and ineffective methods for obtaining necessary materials and equipment. The main difficulties seem to be the following:

a. Inadequate recognition of the need for prompt supply of needed items, best exemplified in the practice which allows the supply organization 180 days to reply to requests for materials or equipment.

b. An inordinate amount of red tape in processing requests for material or equipment, whether it is to be furnished from stock or secured by outside purchase.

c. Inadequate variety in stock supplies, and the use of Tables of Allowances for research and development establishments.

d. Purchasing and supply groups that do not understand the special needs and requirements of research, development, and test work.

It is the opinion of the Committee that all of the difficulties named above stem from the belief that it is cheaper and more efficient to handle together by the same procedure all of the purchasing, supply, and issue, for the Air Force as a whole. The methods used, of course, are those intended to fit the problems of procurement, maintenance, and routine supply, since these are by far the largest part of the job.

For production, maintenance, and routine supply, the items needed can generally be planned for well in advance of the need for them; a number of reviews at progressively higher levels are important to ensure that the items requested by lower echelons are consistent with one another; standardization is important in the interests of economy and simplified logistics; and a purchasing and supply organization which understands these factors and is sympathetic to them is required.

The needs and requirements of research and development in matters of supply and maintenance are almost diametrically opposed to those just enunciated. Since the end product is not completely defined until the research and development work is completed, the materials and equipment which will be required for a given job cannot be fully planned in advance. Lack of a particular item, or a substantial delay in making it available, ordinarily will cost far more in wasted time and effort than the item itself costs. Since the man in charge of the work himself determines what he needs as his work progresses, reviews at higher echelons of his detailed requirements are meaningless; such reviews make sense only when they are directed at the effectiveness of his work as a whole. Quantities required for research and development work are so small that standardization is usually a hindrance rather than a help to over-all economy. The philosophy of the purchasing and supply group must be geared to these factors, if research and development is not to suffer.

Efficiency and economy will both be better served by decentralization of the procurement and supply function. It is recognized that the laws governing the operation of a government agency will have to be observed by the proposed group, but the Committee has seen examples of other government laboratories where the individual project worker is not hampered by the many niggling difficulties that beset Air Force research and development personnel.

The Air Force organization charged with research and development should have its own supply and purchasing group which should operate with a maximum degree of flexibility to meet the unpredictable needs of research and development work.

F. AIRCRAFT DESIGN COMPETITION

Prior to the negotiation of [illegible] type of aircraft, it is Air Force practice to [illegible] which can be entered by any aircraft company [illegible] intended to meet the requirements set up for [illegible] the cost of preparing such designs is paid by the [illegible] themselves, in the hope of winning the competition [illegible] design cost out of profits on contracts for [illegible].

The cost of entering such design [illegible] has grown during the past years to a very substantial figure [illegible] Committee has been informed that the aircraft companies [illegible] dium bomber competition spent together more [illegible] million dollars. In this particular instance, because [illegible] and other factors, no contract was awarded [illegible] covered his costs. Sooner or later, however, these [illegible] primarily out of government contracts, if the [illegible] remain solvent. Some more adequate means for [illegible] the costs involved in entering a design [illegible] ed, particularly if such competitions are [illegible] production contracts.

Another aspect [illegible] to the attention of the Committee. Since [illegible] pay for their work in entering the competition [illegible] submitted remain the property of the [illegible] be used by the Air Force unless a contract [illegible] question. Thus, sound ideas on separate [illegible] mitted by various companies, cannot be [illegible] best end product.

The design competition system [illegible] has largely evolved as a result of the law [illegible] and the interest of the Air Force in maintaining competition [illegible] Congress. Public Law 413, 80th Congress, now enables [illegible] of research and development contracts [illegible] bidding. Preservation of competition [illegible] ance. A system which provides competition, [illegible] work directly and enables the best [illegible] effective way, would seem to be worth considering [illegible].

The Committee [illegible] recommend a specific solution for [illegible] Committee presents some suggestions [illegible] this matter.

The Air Force should [illegible] system of design competition with a view [illegible] more effective [illegible] possible now

aircraft, by preserving the values of competition while reimbursing manufacturers for their design costs, thus making it possible to embody in new aircraft the advanced ideas of all competitors.

G. STABILIZING TECHNICAL STAFFS IN THE AIRCRAFT INDUSTRY

A very disturbing factor in the relations of the Air Force with the aircraft industry is the lack of a consistent program of study contracts, design competitions, and development contracts which contractors need to assure a measure of stability in their engineering staffs.

New aircraft must be introduced into operational use at regular intervals if the USAF is to be kept up-to-date at all times, equipped with modern aircraft. While the Committee recognizes that many complex factors and major considerations influence the frequency with which new models are introduced into the Service, it nevertheless feels that added emphasis should be given to the constructive gains which can be realized from a program which will permit USAF contractors to develop and hold competent engineering and research staffs.

Accompanying the increasing complexity of modern aerial weapons is the need for highly skilled research, design and engineering staffs trained and experienced in the applications of modern technology. These staffs cannot be assembled overnight, nor can they be held together as effective working teams unless the employment outlook for the personnel involved has some degree of stability.

As previously mentioned in Chapter VI, the Committee found that inadequate budgetary support has not permitted a consistent USAF program of study contracts, design competitions, and development contracts. The research, design, and engineering staffs of the aircraft industry are vital to the Air Force and their effectiveness must be maintained. The Committee wishes to point out again that doing this will require a steady increase in the relative expenditure for technical purposes as a result of advances in the technology of air warfare.

Adequate budgetary support should be provided to make possible a consistent USAF program of study contracts, design competitions, and development contracts. This will permit the aircraft industry to stabilize research, design, and engineering staffs, thereby assuring their continued effectiveness and availability to the Air Force.

X. FUNDAMENTAL RESEARCH AND THE AIR FORCE

A. INTRODUCTION

The Committee feels that more emphasis should be given by the Air Force to its support of fundamental research in basic fields of science, in order to bring the over-all program of research and development better into balance. Air Force research and development cannot be maintained at the highest level of competence without being closely associated with the general research effort of the nation's universities. Three steps are recommended as leading toward this important objective: a broader program of contracts supporting fundamental research, the establishment of Air Force fellowships in selected civilian institutions, and the transformation of the Air Institute of Technology into a graduate engineering school of top caliber.

B. CONTRACTS SUPPORTING FUNDAMENTAL RESEARCH

The Committee is aware that the Air Force is now putting a part of its effort into research contracts with university and industrial laboratories. These hold high promise of eventually contributing to the improvement of Air Force equipment. However, many such contracts actually call for applied research or for development, not for fundamental research. Further, they seem to be the least stable part of the Air Materiel Command budget. Relatively minor cuts in the over-all research and development budget have produced major reductions in the support given fundamental research.

The Committee feels that the Air Force should support, to a limited extent but consistently, fundamental research in broad general fields on problems which, without being directed toward definite goals or applications, are of potential interest to the Air Force.

To understand the reasons back of this recommendation, it is necessary to make a distinction between **fundamental research**, which is undertaken with no specific goal in mind beyond that of broadening man's understanding of natural phenomena, and **applied research** or engineering, undertaken for the purpose of achieving desired and defined ends. Applied research, since it is begun with a specific goal in mind, often achieves principally what was visualized at the beginning. Fundamental research, on the other hand, can and does present us with the most surprising variety of new technical tools. Examples of this are numerous and quite familiar. Heinrich Hertz was doing an experiment to verify Maxwell's theory of electromagnetic radiation when he first generated radio

waves; once this discovery had been made, Marconi and others could do the applied research necessary to develop radio communication. Breit and Tuve were investigating the ionosphere when they worked out the technique of pulse ranging which was applied a decade later, by Watson-Watt and others, to radar. Hahn and Strassmann were investigating the chemical nature of the radioactive elements formed by bombarding uranium with neutrons when they made the basic discovery that led, only six and a half years later, to the atomic bomb.

Summarizing then; applied research, if it is successful, achieves definite objectives; fundamental research is responsible for many of the great advances which open entire new fields of engineering possibilities.

Traditionally, and in fact today, the universities of the country are the great centers of fundamental research. In the past, financial support for such work was derived principally from the budgets of the educational institutions themselves. Adding to men's knowledge was considered to be as much a function of the university as was imparting this knowledge to students. Since World War II, however, a pattern of federal support for such work has been established. The most prominent agencies presently sponsoring fundamental research with federal funds are the U. S. Public Health Service, the Atomic Energy Commission, and the Office of Naval Research. A very considerable acceleration of the progress in fundamental research has been accomplished with the help of these agencies.

It has been argued that wasteful and unnecessary duplication of effort would result if other branches of the Department of Defense were to make contracts with educational institutions for fundamental research. In fact, the Office of Naval Research has asked that research in the basic physical sciences be assigned to ONR by the Research and Development Board, as an "area of primary responsibility."

The Committee believes that this would be unwise. Because of the activities of the ONR, the Navy is inevitably in closer touch with the fundamental science of the nation, and with the country's scientists, than is the Air Force. There is no doubt that, like the agencies mentioned, the Air Force is faced by problems requiring fundamental scientific investigations. The Air Force thus will benefit from the direct contact between the Office of Air Research and scientists which a program of research contracts can bring about.

Such contracts should not specify what is to be investigated except in terms proposed by the investigator. They should be awarded less with regard to the description of the project than with regard to the ability and promise of the principal investigator.

After a few years, these contracts would begin to pay dividends in terms of new discoveries of value to the Air Force. This has already been the

experience of the Office of Naval Research. Immediately, however, policy would pay dividends in securing for the Air Force the enthusi interest of highly competent scientists who would otherwise be dea solely with the Navy or the Atomic Energy Commission.

A small fraction—say two or three per cent—of the research and development budget of the Air Force should be consistently assigned for the purpose of making contracts with educational institutions for fundamental research in broad general fields on problems which, without being directed toward definite goals or applications, are of potential interest to the Air Force.

C. AN AIR FORCE FELLOWSHIP PROGRAM

It would be useful to supplement this program of research contr with an Air Force fellowship program in the universities of the coun The Chief of Staff, USAF, has already discussed with certain member the present Congress the legislation which would be required to make s a fellowship program possible. There has been an indication of willingn to support such legislation.

The Committee feels that the recurring requirement for staffing Force research and development facilities with technically qualified yo men would be eased considerably if the Air Force had a number of fell ship holders whose willingness to consider a career with the Air Fo would inevitably be greater than that of other graduate students and p doctoral workers. In connection with this proposed fellowship progr plans might also be worked out for Air Force fellows to engage in sum work at Wright-Patterson Field or at some other research and developm installation, in order to become familiar with Air Force problems, and to permit the Air Force to make an appraisal of the ability and pron of each fellow.

The Air Force should seek legislation empowering it to award a modest number of predoctoral and postdoctoral fellowships to highly qualified students.

D. THE AIR INSTITUTE OF TECHNOLOGY

The Committee has given some thought to the place of the Air Instit of Technology in connection with fundamental research. This Instit has been operated as an engineering school to raise the educational leve Air Force officers in general and to give pre-college refresher courses.

The Committee feels that the Air Force could do something that would be unique in the Department of Defense, and also of the greatest benefit to the Air Force, by gradually turning the Air Institute of Technology into a graduate school of engineering which would rank with the best civilian institutions of this kind. The expense of doing this would not differ substantially from the expense of running the Institute on the present basis; yet the returns, in terms of competent technical men trained in or attracted to the Air Force, would be incalculable.

The staff of such an institution, more than any other single factor, will influence its competence. Civilian universities and technological institutes have learned long ago that a competent staff cannot be assembled and retained unless staff members are enabled to conduct their own research and to guide the research of graduate students. Most of the physical tools for research by the staff and by graduate students are already present at Wright-Patterson Field. All that is needed is a decision to make the Air Institute of Technology into a first-class graduate school of engineering, and the selection and appointment of a first-class dean or provost to take over the job of building up the Institute.

The questions may be asked: Why need the Air Force have its own graduate school of engineering? Why not depend upon civilian institutions, already in existence, for the advanced study and research of interest to the personnel of the Air Force? These questions have two ready and compelling answers. First of all, the Air Force is concerned with the engineering of weapons which often have no civil counterpart. Thus, the study of terminal ballistics, of radiological warfare, and of many other matters, is not the proper business of a civilian institution. Such topics can be best handled in a Service establishment. Second, the Air Force has at Wright-Patterson Field, and will have at the AEDC, facilities for specialized research which are unmatched in civilian institutions, and which cannot be duplicated without large and unjustifiable expense. These facilities should be used for research, and the proposed development of the Air Institute of Technology is the most direct and immediate way of ensuring that they are so used.

The Air Institute of Technology should be made into a graduate school of engineering ranking with the best civilian schools in this category, and having specific objectives derived from the needs of the Air Force.

TAB A

QUESTIONS ADDRESSED TO THE COMMITTEE

LIST OF COMMITTEE MEMBERS

SCHEDULE OF COMMITTEE CONFERENCES AND VISITS

SCIENTIFIC ADVISORY BOARD TO THE CHIEF OF STAFF, USAF

EXCERPT FROM MINUTES OF MEETING HELD 7 APRIL 1949, AT THE PENTAGON, WASHINGTON, D. C.
DR. THEODORE VON KARMAN, CHAIRMAN, PRESIDED

DR. VON KARMAN: May I call the meeting to order. Gen Fairchild will kindly address the Board.

GENERAL FAIRCHILD: Dr. von Karman, members of the Scient Advisory Board:

It is a very pleasant duty for me on behalf of the Chief of Staf extend a very cordial welcome to you all back to the Headquarters of Air Force.

General Vandenberg has asked me to express his very real regret t he is unable to be here personally to welcome you this morning as he planned. Late yesterday an urgent meeting of the Joint Chiefs of S was scheduled before their departure later in the day for meetings Key West. Consequently, he had to revise his planned appearance h However, he had prepared some very brief remarks which he had inten to address to the Board, and he has asked me to give them to you his place.

The United States Air Force is well aware that continued techni superiority is one of the vital decisive elements in modern airpower. Th can be no mistake about the fact that the responsibility for global defense of the Nation axiomatically includes the responsibility for development of the "tools" needed to do the job. I am determined that research and development activities shall have adequate support in fun facilities, and properly-trained personnel, and that the United States Force shall continually increase the efficiency and effectiveness of development work on new aircraft, missiles, and air defense systems.

Within the Air Force, many very important needs frequently have to balanced against each other. For example, the precarious internatio situation brings us face to face with grave operational responsibilit The "cold-war" offers little hope that our limited operational strength or should be even further compromised to meet long-range technical obj

tives. However, the United States Air Force is determined to find means of placing additional emphasis on research and development.

I am familiar with the long-range development plan prepared for the Air Force by the original Scientific Advisory Group in 1945, as it is summarized in "Science, the Key to Air Supremacy." We have hurdled many difficult and pressing operational problems during the few years since the end of the war. We must now take an equally critical look at our equally important long-range technical objectives.

The following questions are uppermost in my mind:

1. Can we now outline an "ultimate plan" for our research and development facilities and draw up a logical plan for gradual development, giving realistic yearly objectives? What organizational patterns are recommended for most effective direction of the Air Engineering Development Center, Nuclear Energy Propulsion of Aircraft, and other research and development projects?

2. What budgetary support should we give research and development activities? What intra-USAF fiscal policies should we follow to insure maximum effectiveness of our research and development programs? We are fully aware that long-range technical objectives can best be achieved through a continuous and stable effort.

3. In this connection, I want to be certain that personnel and administrative policies and practices are adopted which will insure that our facilities are given proper leadership and are staffed by competent military and civilian technical personnel.

I would appreciate your frank and objective advice on these perplexing problems which the United States Air Force faces today because of the dynamic impact of science on the mission of airpower and particularly on our research and development activities.

Thank you very much, Dr. von Karman.

DR. VON KARMAN: Thank you very much, General, for this inspiring statement. I think it is a very important fact that you came here today, and we are very gratified that you did. We are especially gratified to hear the needs of research and development so clearly defined by the highest command in the Air Force. You can be assured that we will go into these difficult problems very carefully and inject something that in past decades was not considered possible. Thirty years ago, maybe even fifteen years ago, the advice of college professors and other scientific men was considered to be rather dreamy in character. Fortunately—I don't say fortunately for

us—I believe this had changed, and it has been recognized that scien planning in unknown fields is really worthwhile. Scientific plan involves the use of basic principles to increase the probability of fin the correct answers to problems. It is not only a guess. If General Van berg and you, and those who are in the top management of the Air F recognize this, we are very glad.

I believe the United States Air Force is a big building, constantly ing new construction. If we can put in a few bricks, especially at the lo levels which carry the weight—if we can help build the foundation— will be very happy.

GENERAL FAIRCHILD: Thank you very much, Dr. von Karma can assure you of the complete support and the deep appreciation of Chief of Staff for the work that you are doing. It is very important to and also to me in my capacity.

DR. VON KARMAN: Thank you, sir.

SCIENTIFIC ADVISORY BOARD TO THE CHIEF OF STAFF, USAF

Members of Special Committee on Research and Development Facilities, Budget and Personn

Dr. Louis N. Ridenour, Chairman
University of Illinois

Dr. George P. Baker
Harvard School of Business Administration

Dr. James H. Doolittle (Lieut. General, Ret.)
Shell Union Oil Company

Dr. James B. Fisk
Bell Telephone Laboratories

Dr. Carl F. J. Overhage
Eastman Kodak Company

Dean Ralph A. Sawyer
University of Michigan

Dr. Frank L. Wattendorf
Air Materiel Command

Professor John M. Wild
Cornell University

Mr. Raymond J. Woodrow
Princeton University

SCHEDULE OF COMMITTEE CONFERENCES AND VISITS

11 July 1949—The Pentagon, Washington, D. C.

0900-1150—Initial meeting. General discussion of task and form
tion of plans. Introductory talk by Brig. Gen. D. L.
summarizing the position and problem of research
development in USAF. Discussion by Brig. Gen. Ja
R. Phillips on place of RDB in the Department
Defense and its relationship to USAF. Dr. Hugh
Dryden gave a short account of the tie-up between
NACA and the Air Force.

1400-1635—Continuation of initial meeting. Brig. Gen. Putt
scribed organization and functions concerned w
research and development in the Air Force. Gen
Hoyt S. Vandenberg addressed the committee inform
outlining its task and amplifying his earlier stateme
to the Scientific Advisory Board. Dr. Frank L. Watt
dorf gave a short discussion of the A.E.D.C.

12 July 1949—The Pentagon, Washington, D. C.

0900-1200—The Committee was briefed in the War Room on pres
strategic thinking by Maj. Gen. S. E. Anderson.

1300-1500—Presentation by Maj. Gen. R. C. Coupland, Directo
Armament, on "The Future of Armament Research a
Development." Col. M. R. Williams presented t
budget situation as it applies to Armament.

1520-1700—Maj. Gen. D. M. Schlatter, Assistant for Atomic Ener
Deputy Chief of Staff, Operations, presented the Aton
Energy Program in its relationship to the USAF. C
A. A. Fickel reviewed certain specific elements of t
program.

13 July 1949—The Pentagon, Washington, D. C.

0900-1200—Presentation by Brig. Gen. W. L. Richardson, Assista
for Guided Missiles, Deputy Chief of Staff Operation
on "The Joint Long Range Proving Ground for Guide
Missiles," followed by general discussion of this facilit

1300-1400—Informal discussion on the Office of Naval Researc
by Dr. Frank Waterman, Navy Department.

1420-1535—Presentation by Col. M. C. Demler, Chief, Propulsio
Branch, Directorate of Research and Development, o

the NEPA Project. This included the organization, mission, and general relationship to other USAF activities.

1400-1600—A concurrent session was held in which Brig. Gen. H. G. Armstrong, Acting Deputy Surgeon General, presented a paper on "Medical Research in the USAF" before the Aeromedicine and Social Sciences Panel of the Scientific Advisory Board.

1600-1700—Col. P. S. Entrick, formerly of Lt. Gen. Curtis E. LeMay's staff when he was Deputy Chief of Staff for Research and Development, discussed the operation of this organization as it was then constituted.

14 July 1949—The Pentagon, Washington, D. C.

0900-1145—Presentation by Col. L. P. Hopwood, Deputy Director, Personnel Planning, Deputy Chief of Staff, Personnel, on the personnel and administrative policies and practices as they relate to USAF research and development.

1415-1530—Maj. Gen. F. H. Smith, Jr., Assistant for Programming, Deputy Chief of Staff, Operations, presented the responsibility of Operations as it affects the research and development program, in particular with regard to War Plans and Military Requirements.

1530-1630—Presentation by Brig. Gen. J. W. Wood, Director of the Budget, on the budgetary aspects of the Air Force research and development program.

1645-1715—Brig. Gen. Putt summarized certain fundamental aspects of research and development problems for the Committee.

15 July 1949—The Pentagon, Washington, D. C.

1000-1200—The Committee attended a formal presentation by Dr. K. T. Compton, Chairman of the RDB, on the organization and function of this organization and the aspects of the research and development budget.

1330-1600—**Naval Ordnance Laboratories, White Oaks, Md.**

The Committee visited this station to discuss the management policies currently in effect in Naval Research and Development program.

18 July 1949—Air Materiel Command, Wright-Patterson AFB, Dayton, Ohio

0830-1200—After an introduction to the AMC by Maj. Gen. F. O. Carroll, the following presentations were made: "De-

velopment of New Aircraft, Missiles, and Air D
Systems"—Introduction by Brig. Gen R. P. Swo
"New Aircraft" by Col. F. G. Smith, Chief, A
Projects Section; "Missiles" by Col. H. J. Sands,
Guided Missiles Section; "Air Defense System
Col. G. A. Blake, Chief, Electronic Operations,
search and Development Facilities" by Col.
McNickle, Engineering Plans. "Personnel Aspects
Research and Development Program" by Col.
McNickle. "Training of Technical Personnel in Su
of Research and Development" by Maj. Gen.
Bevans, Chief, Personnel and Administration.

1345-1600—The Committee was briefed on the Torrance air
facility, on the proposed Electronics Center at Gr
AFB, on the guided missiles test facilities at Hollo
and the Joint Long Range Proving Ground. The F
and tentative FY 50 research and development bud
were discussed.

**19 July 1949—Air Materiel Command, Wright-Patterson A
Dayton, Ohio**

0800-1030—The Committee was taken on a flight-line inspection.

1030-1100—The Committee was briefed on the organization, budg
personnel, and facilities of the Flight Test Division.

1100-1200—Presentation by Col. J. F. Taylor, Jr. on the All Weath
Flying Division and its operation at the Clinton Coun
AFB, Wilmington, Ohio.

1330-1410—Presentation by Col. O. C. Maier on the Office of A
Research.

1410-1530—The Committee was briefed on the Armament Te
Center at Eglin Field by Col. R. E. Jarmon, Armamen
Laboratory.

1530-1600—Col. O. C. Maier, Engineering Plans, discussed some o
the problems facing research and development withi
the Air Force, and possible solutions to them.

20 July 1949—The Pentagon, Washington, D. C.

0900-1030—Presentation by Maj. Gen. F. L. Ankenbrandt, Director
of Communications, Deputy Chief of Staff, Operations,
on the generation of requirements for communication
equipment.

1030-1130—Presentation by Mr. R. Dorfman from the Office of the Assistant for Operations Analysis, Deputy Chief of Staff, Operations, on the research and development aspects of Operations Analysis.

1400-1600—Col. H. L. Sanders and Col. C. A. Thorpe, Operational Requirements Division, Deputy Chief of Staff, Operations, gave a presentation on the organization and function of this division and its relation to research and development.

21 July 1949—Air University, Maxwell AFB, Alabama

0900-1230—Gen. G. C. Kenney gave a brief introduction and historical background of the Air University. Several Air University Staff officers presented the organization and function of this installation. A general discussion was held on the problems of research and development in the USAF.

1400-1500—Discussion of the Human Resources Research Institute, Air University.

22 July 1949—Air Proving Ground, Eglin AFB, Florida

0800-1200—The Committee inspected the facilities at this base, in particular the flight-line and the climatic hangar.

1300-1600—Maj. Gen. W. E. Kepner gave a short background sketch of the Air Proving Ground. A.P.G. Staff officers presented the organization and responsibilities of the Command in the area of research and development interest. Several reports were circulated to show the type of work done.

23 July 1949—Air Proving Ground, Eglin AFB, Florida

0800-1100—The Committee witnessed an Air Demonstration by the A.P.G. Command at Range 52.

1200-1430—The Committee was escorted on a tour of inspection of the static display of various types of equipment being tested for operational suitability at the A.P.G.

25 July 1949—Field Office for Atomic Energy, Kirtland AFB, New Mexico

0800-1630—Brig. Gen. H. G. Bunker presented a description of the organization and the function of the Field Office. Staff officers gave presentations on the relationship of these

facilities to the AMC, the AEC, and other agenci
training program of the Field Office; and the r
of the work of this facility to the overall resear
development picture. An inspection of the base fa
was also conducted.

26 July 1949—Holloman AFB, New Mexico

0900-1200—Col. W. H. Baynes described the organization a
signment of the facility. Other Staff officers pres
discussions of personnel, supply, and installation
lems peculiar to an isolated base of this nature. Pre
tions were also made on the scope of technical ac
range instrumentation, etc.

1300-1630—The Committee inspected the base facilities and so
its operations.

27 July 1949—Atomic Energy Commission, Los Alamos, New Mexico

0830-1400—Dr. N. F. Bradbury discussed the organization, ma
ment, personnel, and budgetary problems assoc
with the research and development effort of this isc
installation. The Committee inspected the Los A
community.

28 July 1949—Muroc AFB, California

0945-1200—Col. S. A. Gilkey outlined the functional and phy
organization of the base, stressing items which
peculiar to isolated research and development faci
This was followed by an inspection of the faci
including housing and community accommodations

1300-1630—Staff officers made presentations on personnel, b
etary, and facilities aspects of the base operation.

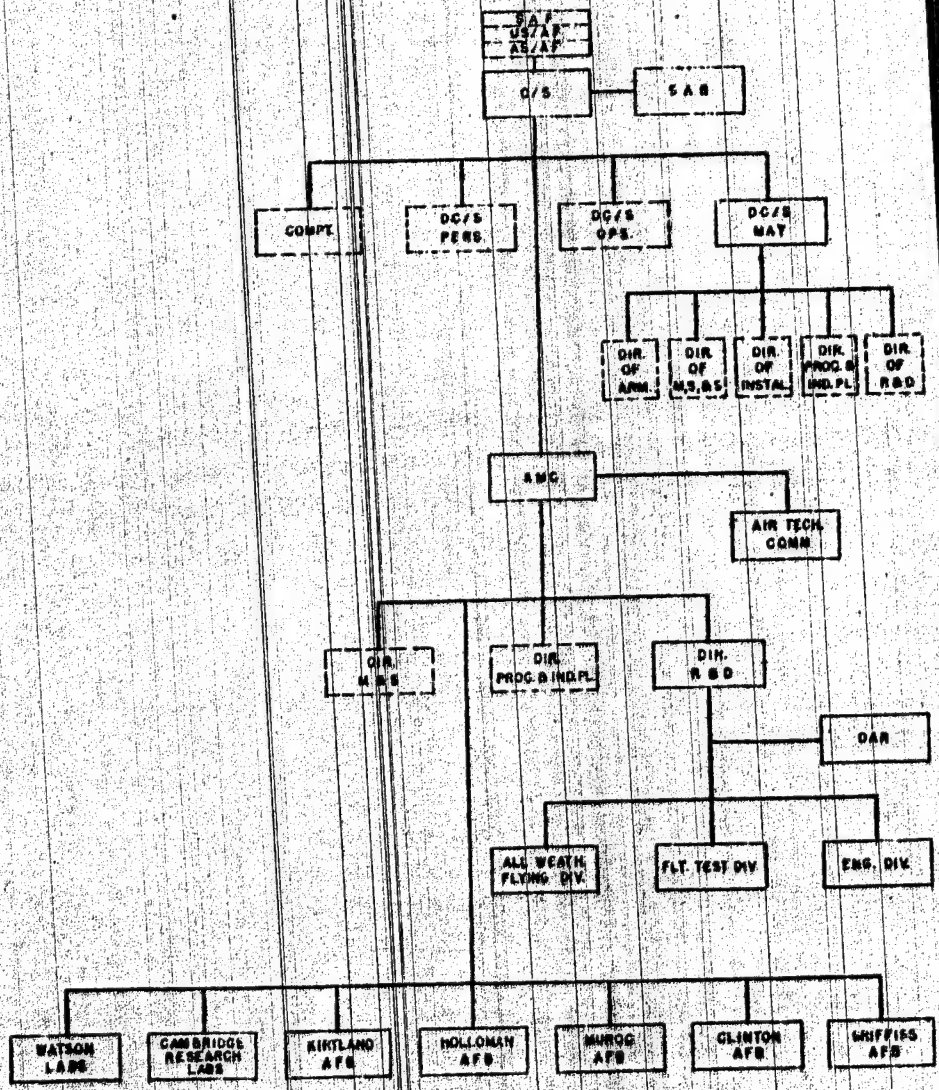
29 July 1949—Naval Ordnance Test Station, Inyokern, California

1100-1200—Presentations on the organization and mission o
facility were made, as well as on personnel and b
etary policies.

1300-1630—Additional discussions on budget and fiscal prob
were held with Staff officers. There was an inspe
of laboratory and range facilities, and the suppo
community.

TECHNICAL MANAGEMENT OF R & D—PRESENT ORGANIZATION

(September 1, 1949)



STATEMENT OF FUNCTIONS OF HEADQUARTERS USAF STAFF AGENCIES HAVING RESEARCH AND DEVELOPMENT RESPONSIBILITIES

(Reference "Headquarters U. S. Air Force Organization and Functions," dated 1 August 1949)

Primary responsibility in research and development matters rests in th Director of Research and Development who "under the supervision of th Deputy Chief of Staff, Materiel is the representative of the Chief of Staf United States Air Force, in all matters pertaining to research and develop ment by or for the USAF and the USAF Reserve Forces."

There is a dispersion of responsibility, however, for the research an development function between a number of other Headquarters USA Staff agencies. For example:

1. The Technical Development Division under the Director o Armament, Deputy Chief of Staff, Materiel, among other things "Plans for, initiates and monitors research and development o the various armament items as specified in the functional state ment for the branches of this division."

   "Monitors service tests to be conducted on new items. Receive reports of these tests and makes recommendations as to approva or disapproval of findings. Takes appropriate action with devel oping agencies or other activities when indicated."

   "Represents the USAF on the several committees, panels, an working groups to coordinate research and development activi ties in these fields."

   "Reviews and coordinates research and development portion o the Air Force budget to ascertain whether or not sufficient funds are included in the Air Force budget to cover research and devel opment of the items for which this division is responsible. Pro vides information for the defense of the Air Force budget tha pertains to the research and development programs for which this division is responsible."

   "Recommends allocation of Air Force funds to be transferred to outside development agencies to meet specific USAF needs fo research and development programs in this field."

2. The Surgeon General, USAF, among other things, "Recommends policies for and exercises supervision of all research conducted by or for the Air Force required for the accomplishment of the mission of the Medical Service."

   This function is carried out by the Medical Research Division, which, among other things, "Facilitates and promulgates policies for and exercises broad supervision over research conducted by or for the Air Force in the following fields, including background, basic and applied research: the biological and allied physical and social sciences; the basic and clinical medical sciences; aviation medicine and associated sciences; and the military medical sciences."

3. The Materiel Branch, Assistant for Atomic Energy, Deputy Chief of Staff, Operations, among other things, "Exercises responsibility for supervision of the entire USAF materiel program as influenced by atomic energy, including: Analysis of policies, programs, and technical standards of research, development design, experimentation and testing of atomic weapons, and other military applications of atomic energy; Development and use of installations and facilities which further Air Force participation in the atomic energy program . . ."

4. The Guided Missile Division, Assistant for Guided Missiles, Deputy Chief of Staff, Operations, among other things, "Formulates, directs, supervises, and coordinates the overall guided missile program of the Air Force; analyzes and evaluates technical, logistical, and operational data on guided missiles . . ." This function is carried out by two Branches: (a) Requirements Branch, Guided Missile Division, which among things, ". . . analyzes guided missile projects to determine the degree to which they meet established objectives and missions of the USAF and recommends appropriate remedial action; monitors US and foreign guided missile developments;" and (2) the Operations Branch, which, among other things, ". . . monitors USAF guided missile operational tests and the allocation of operational funds for guided missiles . . ."

5. The Operations Analysis Group, Deputy Chief of Staff, Operations, among other things, "Undertakes scientific studies of USAF equipment, weapons, tactics, and strategy as requested by Air Staff sections. The objectives of these studies are to improve the item under study. . . . Maintains close liaison with research agencies and scientific societies, individual scientists, technical experts, and analysts to provide a flow of scientific and

technical information between HQ USAF, all operations analysis sections, and other research agencies.

6. The Training Evaluation and Analysis Group of the Training Division, Director of Training and Requirements, Deputy Chief of Staff, Operations, among other things, "Coordinates and controls all matters pertaining to training research and development . . . with a view to improving training methods, equipment, and administration. Monitors the preparation and submission of training research and development budget estimates and recommended allocation of funds to support approved programs."

7. The Special Projects Branch, Machine Accounting Division, The Comptroller, among other things, "Plans and directs the development of all methods and techniques in various fields . . . where electrical and/or mechanical punch card accounting is concerned, including such subject matter fields as Strategic Vulnerability, Projection of Program Requirements . . . application of electrical and/or mechanical equipment toward the use of mathematical formulae in determing program requirements and other research projects. Conducts continuous report engineering programs designed to develop and approve mechanical accounting methods and procedures in subject matter fields for use by the mechanized Comptroller system."

8. Engineering and Technical Requirements Branch, Communications Systems Division, Director of Communications, Deputy Chief of Staff, Operations, among other things, "Performs the engineering analysis and review of projects submitted for establishment of fixed communications systems by the Air Commands."

"Obtains and reviews information of new developments and improvements in communications equipment; studies and recommends application to USAF operational requirements; disseminates technical information of interest to USAF Commands; monitors development of communications equipment by USAF and Army agencies."

"Prepares and processes military characteristics for and monitors development and tactical proof testing of all communication systems equipment."

"Reviews technical literature, domestic and foreign, dealing with communications systems equipment and developments, and analyzes information thereon as to trends and implications with reference to USAF communications systems."

9. Navigation and Communications Branch, Electronics Systems Division, Director of Communications, Deputy Chief of Staff, Operations, among other things, "Monitors the development, engineering, and operational tests of all ground/air components of UHF communications equipment and the UHF program generally."

10. Aircraft Control and Warning Systems Branch, Electronics Systems Division, Director of Communications, Deputy Chief of Staff, Operations, among other things, "Recommends the initiation of development projects, monitors such projects and maintains liaison with agencies engaged in research and development of electronics equipment and systems intended for aircraft control and warning."

TAB C

AIR FORCE REGULATION 80-4, RESEARCH POLICIES

TAB D

SUGGESTED BUDGET AND ACCOUNTING STRUCTURE

SUGGESTED BUDGET AND ACCOUNTING STRUCTURE

An annual operating budget structure patterned in general after
Major Program Series—600, with changes as explained below:

610—Research: For expenses of basic and applied researc
science and engineering required in support of the USAF, inclu
all direct and indirect operating costs of such research.

620—Components Development: For expenses incider
the development and engineering test of all items of aeronau
equipment and components which are not readily identifiable
any specific weapon systems, aircraft or guided missiles, inclu
all direct and indirect operating costs of such development and

640—Weapons System Development: For all expense
cident to the development and engineering test of complete wea
systems and those related components which are readily identi
with a particular weapon system, including all direct and ind
operating costs of such development and test (this category w
absorb most of the development work now carried out with
duction and procurement funds, and most of the special pro
presently carried under 670—Special Projects; the remainde
these, where appropriate, would be distributed among the o
categories listed).

650—Operational Engineering: For all expenses incider
large scale operations such as "Crossroads" established to obtain
solution of major research and development problems.

660—Human Factors Research and Development: For
penses incident to basic research, applied research and developm
in the fields of human factors, including human resources,
including all direct and indirect operating costs of such resea
and development.

680—Command and Staff Management and Operati
An overhead account, for expenses necessary to operate all c
mand and staff activities which are not directly associated with
of the Major Budget Programs, including an allowance for pre
inary analysis and contingencies to be allocated to Major Bud
Programs at the discretion of the Command.

An annual capital construction budget for all facilities, housing and base construction patterned after the same Major Program operating budgets, to include capital construction items required for the support of the activities covered by the operating budget.

Appropriation authorizations and the necessary changes in accounting so that moneys appropriated by Congress for the operating and capital construction budgets shall remain available until expended. Legislation as covered by Sec. 206 of H.R. 1437 of the 81st Congress will be necessary for such a change.

An internal breakdown of budgets and accounts within each Major Program dependent to some extent upon the type of organization handling the work. In general, each segment of the organization large enough to have a facility which requires substantial funds and personnel for maintenance, housekeeping, repair and utilities should have its own internal overhead budget and accounts for these types of expenses, which cannot be directly associated with individual programs or projects carried on within the organization, and to provide some allowance for preliminary analysis and contingencies, similar to the Major Program 680—Command and Staff Management and Operation. In building up the budget structure to the higher levels of Command, however, such overhead costs should not be budgeted separately but should be prorated among the various direct activities carried on.

The system described above contemplates that personnel salaries will not appear as a separate budget item at any level but the lowest in the budget structure. By law, however, the number of personnel must be budgeted in terms of personnel ceilings. Since, as earlier stated, budgets for funds and personnel should not be separated, the procedures for preparing personnel budgets and for controlling the budgets once approved should follow exactly parallel lines to the budgets for moneys, including the overhead technique for personnel in indirect and supporting activities.

A budgetary accounting system, to account for obligations and expenditures along lines substantially identical with the budget structure, together with such other parallel accounting systems as may be necessary for informational purposes only and not for control.

EVALUATION OF SUGGESTED BUDGET AND ACCOUNTING STRUCTURE

The Budget and accounting structure outlined above has been suggested in the body of this report as a method of achieving most of the important objectives which have been cited as ends toward which the budget and accounting system should be aimed. To test this statement, the suggested structure is discussed below with reference to each of these objectives.

> "Objective 1—The maximum amount of simplicity in preparation of budgets and in accounting for costs, to make management effective and to avoid what presently appear to be overly complicated procedures requiring a large percentage of the time of important research and development personnel from top to bottom."

The structure suggested follows a unitary approach, subdivided pa marily by the various functions and subfunctions which are performe in actually carrying out research and development work. It, therefor parallels closely a logical organization for research and development, that there will be a minimum overlap of budgets between portions of t organization. As a result, budgets can be more readily and quickly prepare the effects of adjustments in budget can be more easily analyzed, an moneys, once appropriated, can be more quickly parcelled out. Basic r search in human factors has been lumped with applied research an development in this field rather than with basic research in science an engineering, since this more closely follows a functional organization.

> "Objective 2—A maximum amount of flexibility, since the very nature of research and development work makes it almost impossible to predict accurately the costs involved. If the results and the costs of individual research and development programs could be predicted with accuracy, no research or development would be needed."

Satisfying the objective of simplicity in the budget and accountin structure automatically achieves a certain measure of flexibility. Compl cated systems are more difficult to set up, and once set up are much mor difficult to change. Two other factors have been added, however, to increas flexibility. First, management and operation (except for top level com mand and staff) together with maintenance and operation and repairs an utilities are not budgeted separately. As a result the establishment respon sible for particular research and development projects should have muc greater freedom to change as the work progresses and the need for chang becomes apparent between, for example, the extent of work contracte out and the extent done internally; the funds required for maintenance an operation and the amount spent for research and development, if th requirements for maintenance and operation become greater or less tha had been originally expected; etc.

A second important factor fostering flexibility has been the inclusio (at all levels of command if the general pattern is followed) of an amoun for preliminary analysis and contingencies. Preliminary analysis by com petent personnel, including a preliminary analysis contract to an outsid organization where necessary, is frequently essential prior to the establish ment of a research or development project, so that the project can b

formulated in reasonable and sensible terms. Neglecting to provide for such preliminary analysis will result either in poorly formulated projects or in "bootleg" operations under the guise of already recognized projects.

A contingency allowance is also essential, since the cost of research and development projects can never be accurately estimated in advance. Important projects can be seriously handicapped and the responsible personnel discouraged over the lack of funds, the need for which arises only during the course of work; increased potentialities of certain projects which become apparent as the work progresses can frequently not be taken advantage of without some source of added funds. It may be argued that such requirements can be taken care of by diversion of funds from other projects. Although such action may often be required, it is poorer management practice, requires much more time and effort, disturbs continuity and stability, and creates ill will and dissatisfaction among the groups who must relinquish funds.

> "Objective 3—Consolidation of responsibility with authority, so that the individual or organization having a job to do has control over the funds necessary to accomplish that job."

In few other fields is it as necessary for efficient and effective performance to pick the most qualified personnel for responsible positions, and then to give them the authority and the funds necessary to accomplish their complete job. The type of budget and accounting structure recommended is as effective a way of accomplishing this objective as has been devised. Those primarily responsible for the research and development work will have within their control, subject only to a single higher authority, the funds and personnel necessary to do the job as they best see fit. They will not be subject to separate and diverse controls on the funds and personnel which they must devote to (1) research and development, (2) work intended ultimately for different strategic operations, (3) maintenance and operations, etc. Such separate and diverse controls relieve one of authority, and lead inevitably to the absence of a sense of responsibility.

> "Objective 4—A method of emphasizing the types of warfare operations, in terms of the amounts of money allocated to research and development projects which will support such operations. The Research and Development Board Master Plan categories appear to be aimed primarily at this objective."

The budget and accounting structure suggested does not in itself meet this objective. But any budget structure based on such an objective will be unrealistic in terms of the functions actually performed in research and development work. It will, therefore, become a substantially meaningless tool for management purposes. A budget structure patterned after

types of warfare operations is designed for warfare operations, no
research and development. Just as the type of organization, the typ
personnel, the arrangements for procurement and supply, etc., necessar
research and development should be adapted to its needs, so should
design of the budget structure. Even to account for expenditures in
a fashion will be very difficult.

Despite the above objections, the objective is a valid objective,
means for attaining it must be realized. The best means, however, is no
budget structure. The means should be a careful integration of the
for research and development, and the projects within those areas,
strategic requirements, but not in terms of the money and personn
carry out the work. The solution lies in the area of establishing req
ments and setting priorities.

> "Objective 5—The necessity of providing continuity of support for areas of research and development, particularly in the fields of basic research and components development, where the type of warfare operation or the type of weapon system which will use the results of such work cannot be readily identified. Since almost all new types of warfare operations and of weapon systems will evolve from such basic research and components development, the importance of this support is readily apparent."

The suggested budget structure will achieve this objective to a
stantial extent, since it is erected upon functional areas of work.
continuity provided will, therefore, be readily apparent at the hig
levels of command without too much detailed analysis of individual p
or projects. Beyond this point, it will be management decision and
budget structure that gives continuity of support.

One aspect of present laws is a substantial handicap to continuity
research and development work, namely the fact that funds appropri
by Congress are available for obligation only during the fiscal year
which appropriated, and available for expenditure for only two y
longer. The third paragraph under Suggested Budget and Account
structure above recommends appropriation authorization and the necess
changes in accounting so that moneys appropriated by Congress for
operating and capital construction budgets shall remain available u
expended. Some of the best reasons for such a change were given i
report to the Army on research and development work, which can be quo
as follows:*

*Page 38—Report of the Advisory Committee on Contractual and Adm
strative Procedures for Research and Development for the Department of
Army, 15 October 48.

"(a) Many research and development projects require a longer period of time than the two years presently allowed. Contractors are, therefore, reluctant to undertake contracts for the performance of such projects for fear that funds for their completion may not be available in future years.

"(b) As stated in the report accompanying S-1560—80th Congress, 'not infrequently a research or developmental project would reach a point beyond which it was useless to proceed further—in effect the project had become a "blind alley." Under current procedures, if such a project is terminated, the funds revert to the Treasury. The practical result is inertia in the matter of promptly ceasing and terminating a project which has proved fruitless. In the meantime, a related project may have developed possibilities far beyond those originally anticipated.'

"(c) A large number of research and development contracts are necessarily placed on a cost or cost-plus-a-fixed-fee basis because of the impossibility of adequately predicting the costs involved. As a result, the work originally called for often cannot be completed within the amount initially committed under the contract. Under present procedures this amount frequently cannot be increased at the time that it is discovered to be inadequate, because no funds remain in the appropriation made available during the fiscal year in which the contract was placed.

"(d) Under current procedures, the fact that funds appropriated by Congress revert to the Treasury unless committed before the end of the fiscal year for which they were appropriated often results in a scramble near the end of the fiscal year to make sure that all funds appropriated are committed. As a result, unwise or inadequately considered commitments may often be made near the end of the fiscal year to avoid reversion of funds to the Treasury. Though not peculiar solely to research and development, the intangible and often unpredictable nature of research and development as emphasized in the first principle of Section I of this report is strong justification for not tying down the Army or its several Technical services to the fiscal year commitment period in the areas of research and development—when budgets are prepared, research and development commitments can never be completely planned."

"Objective 6—The importance of providing continuity of support for research and development establishments, both within the Air Force and in contractor's organizations. Competent scientists and engineers cannot be attracted or held, and well-planned programs within such establishments cannot be carried out without such continuity."

Satisfying objective 5 above will also satisfy this objective to an ciable extent. Control over direct and indirect costs and personnel various levels of Command will also aid substantially, since those in can balance requirements between these areas to achieve a more reas and sensible stability than can be imposed from above. Insofar as cont establishments are concerned, including within the research and de ment budget funds which are used for development but are pre allocated out of production appropriations will make for better and stable relations between contractors and the USAF research and dev ment organization.

"Objective 7—The necessity of accounting for direct costs, indirect costs, personnel, and facilities, etc., so that management can have some measure of the efficiency of operations and some method for improving efficiency."

Paragraph 6 under Suggested Budget and Accounting Stru provides for accounting systems other than the budgetary accou systems, so long as these other systems are used for information only not control. The first part of this objective can thus be realized. The se part of the objective, i.e., the taking of necessary action on the bas information so acquired, should not be accomplished by making sources of information the means of control. Other management niques, primarily through the choice or substitution of more compe personnel and the reallocation of functions when necessary, are infin more effective.

SUMMARY

A functional, or performance, budget and accounting structure has been proposed to best achieve the objectives which have been cited for such a structure. It has been evaluated and, it is hoped, shown to meet most of these objectives; the one objective and part of another which the proposed structure does not meet being analyzed as improper objectives for such a structure and better achieved through other means.

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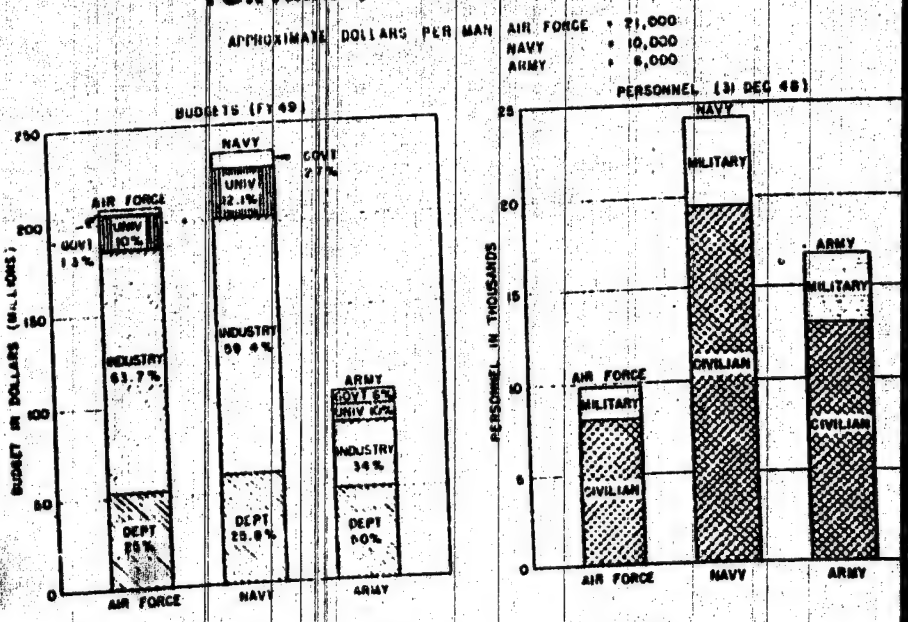
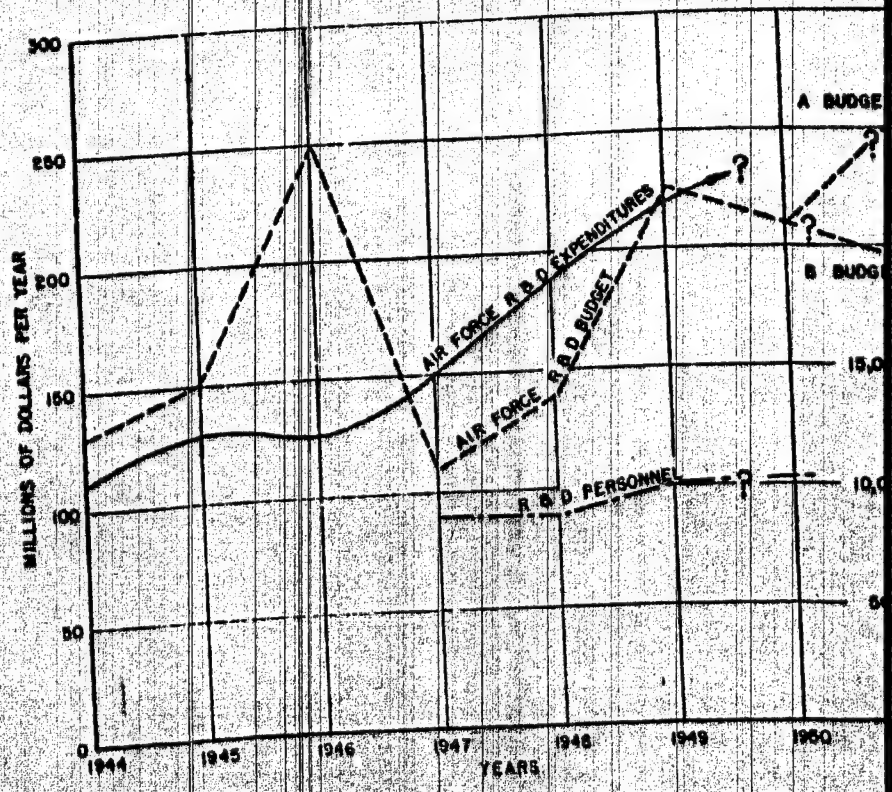
TAB E

RESEARCH AND DEVELOPMENT PERSONNEL, BUDGET AND COST STATISTICS, AND TRENDS

R & D BUDGET AND PERSONNEL ALLOTMENTS FOR ARMY, NAVY, AND AIR FORCE



BUDGETS AND EXPENDITURES COMPARED WITH PERSONNEL TRENDS



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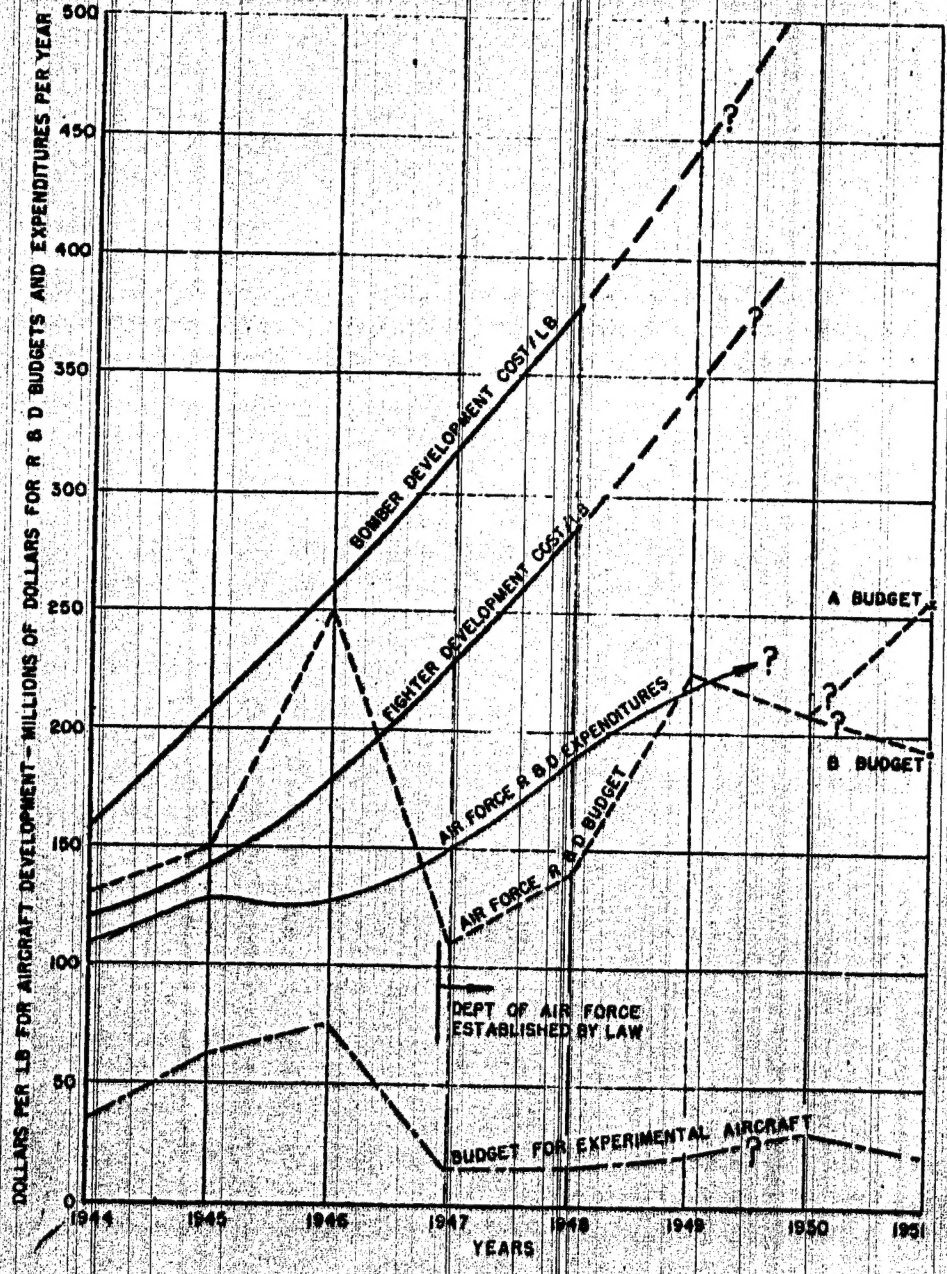
TAB F

SUGGESTIONS FOR AIRCRAFT DESIGN COMPETITIONS

TRENDS IN COST vs BUDGET FOR RESEARCH AND DEVELOPMENT



SUGGESTIONS FOR AIRCRAFT DESIGN COMPETITIONS

1. Opening the "competition" by a request for proposals that w
cover not so much the actual design of the proposed aircraft as the me
by which the design and system study, mentioned below, would be
ducted, how much it might cost, what key personnel would be used
This opening step might well be introduced in many instances
round-table discussion between Air Force and industry representativ
the problems faced by the Air Force (as was done, the Committee u
stands, in the interceptor conference) rather than by the circulatio
desired military characteristics. The cost of submitting such prop
would be very substantially lower than the cost of entering a design
petition, and as such could well be borne by the industry, thus constit
a spur to competition. Few if any ideas from competitors' proposals, w
could advantageously be combined, would be anticipated at this stag

2. Negotiation of design contracts with several of the companies
mitting proposals in the first stage. The choice of contractors woul
based upon evaluation of the proposals submitted, combined with ev
tion of the competence of the organizations involved to carry the dev
ment through effectively. The contracts entered into should reimbur
or a substantial portion of the costs involved, and provide that the Air
could use for its purposes the various ideas submitted.

3. Following the completion of the design contracts, a conference
be desirable, with participation of representatives of the Air Force an
design contractors, for the purpose of analyzing the combination of
able ideas included in the several designs.

4. A development contract or contracts would logically follow.
choice of contractors should be reasonably evident from what has
before. For all important cases, two such development contracts a
desirable, in the interests of competition and in recognition of the fac
designs, no matter how attractive on paper, do not assure success. Th
the cost of two development contracts will bulk large in the researc
development budget, their efforts on the total Air Force budget w
very small in comparison with the increased probabilities for a
equipped Air Force.

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